Washington State Plan for Priorities for Biomonitoring

November 2003

Biomonitoring Planning Project Team
Washington State Department of Health

Romesh Gautom, MS PhD, Principle Investigator
Public Health Laboratory
Romesh.Gautom@doh.wa.gov
(206) 361-2885

Denise Laflamme, MS
Office of Environmental Health Assessments
Denise.Laflamme@doh.wa.gov
(360) 236-3174

Steven Macdonald, PhD
Office of Epidemiology, Non-Infectious Conditions
Steven.Macdonald@doh.wa.gov
(360) 236-4253

Pamela Navaja, BS
Public Health Laboratory
Pam.Navaja@doh.wa.gov
(206) 361-2910

James Robertson
Division of Epidemiology, Health Statistics and
Public Health Laboratory
Jim.Robertson@doh.wa.gov
(360) 236-4205

Harold Ruark, MS
Public Health Laboratory
Harold.Ruark@doh.wa.gov
(206) 361-2848

Marina Silverstone, MS
Public Health Laboratory
Marina.Silverstone@doh.wa.gov
(206) 361-2894

James VanDerslice, PhD
Office of Environmental Health Assessments
Jim.VanDerslice@doh.wa.gov
(360) 236-3183

Juliet VanEenwyk, PhD
Office of Epidemiology, Non-Infectious Conditions
Juliet.VanEenwyk@doh.wa.gov
(360) 236-4250

Washington State Plan for Priorities for Biomonitoring

November 2003

Division of Epidemiology, Health Statistics and Public Health Laboratories
Division of Environmental Health

For more information or additional copies of this report contact the Washington State Department of Health:

Juliet VanEenwyk
Office of Epidemiology
(360) 236-4250
juliet.vaneenwyk@doh.wa.gov

James VanDerslice
Office of Environmental Health Assessments
(360) 236-3183
jim.vanderslice@doh.wa.gov

Mary Selecky
Secretary of Health

Maxine Hayes, MD
State Health Officer

TABLE OF CONTENTS

Washington State Plan for Priorities for Biomonitoring

Executive Summary

This report provides information on priorities for biomonitoring in Washington State that have been adopted by the Washington State Department of Health (Department). The Department identified these priorities based on input from an Advisory Committee and key stakeholder interviews. These groups included people from public and private organizations and agencies with an interest in or knowledge of the relationship between environmental exposures and health in Washington. The Department developed this plan in 2002 and 2003 under a grant from the Centers for Disease Control and Prevention. This document will serve as the basis for prioritizing biomonitoring implementation projects by the Department over the next several years as funding is available. It is also hoped that this document will be useful to other Washington State agencies and organizations interested in developing biomonitoring projects.

Given the high degree of concurrence between the Advisory Committee and the key stakeholders regarding important issues and criteria for selecting priorities, the Department has adopted the priorities recommended by the Advisory Committee. In rank order beginning with the highest priority, these are

1. Monitoring breast milk for lipophilic compounds
2. Conducting a statewide survey modeled on the National Health and Nutrition Examination Survey (DOH HANES) for mercury in blood, urine and/or hair
3. Monitoring urinary arsenic levels in individuals with known exposures to arsenic
4. Monitoring children for urinary organophosphate pesticide metabolites
5. Monitoring mercury in the hair of Asian and Pacific Islanders
6. Monitoring mercury in the hair of American Indians
7. DOH HANES for urinary cotinine
8. Monitoring agricultural workers for urinary organophosphate pesticide metabolites
9. Cholinesterase monitoring of pesticide applicators
10. Emergent issues

The Department recognizes the importance of working with communities beginning with the early planning stages of a biomonitoring project to build trust and to ensure that the community clearly understands the value of biomonitoring. The Department also recognizes the need to balance costs, the interests of diverse communities, and funding in selecting specific projects for implementation. Finally, implementing any of these priorities requires careful planning to develop protocols for sample collection, transportation, storage and laboratory analysis; to estimate study sample sizes and develop recruitment methods; to resolve data issues such as data handling, analysis and dissemination; and to assure privacy protections.

Washington State Plan for Priorities for Biomonitoring

Biomonitoring focuses on the presence of environmental chemicals in the human body. In this plan the term "biomonitoring" refers to the assessment of people's exposure to toxic substances through the laboratory measurement of these substances or their metabolites in human specimens, such as urine, serum, saliva, or tissue samples. Attachment 1 includes a discussion of the uses of biomonitoring.

Purpose

This report provides information on priorities for biomonitoring in Washington State developed in 2002 and 2003 under the Centers for Disease Control and Prevention (CDC) grant #RO8/CCR02404. This document will serve as the basis for prioritizing biomonitoring implementation projects by the Washington State Department of Health (Department) over the next several years. It is also hoped that this document will be used by other agencies and organizations in Washington State interested in developing biomonitoring projects.

Background

In 2001, the CDC initiated a grant program to promote the development, implementation, and expansion of state-based biomonitoring programs to help prevent disease resulting from exposure to toxic substances. During the first two years, the grant program focused on assessing the need for biomonitoring within the state and developing a plan for implementing and expanding biomonitoring capacity to meet these needs. The Department successfully applied for funding for the two-year planning grant, subsequent to which the Department's Public Health Laboratory, Office of Environmental Health Assessments and Office of Epidemiology conducted a process for identifying priorities for biomonitoring in Washington State and developed an initial implementation proposal based on these priorities (available upon request).

Process

Identification of Priorities

Priorities for biomonitoring were developed through a two-pronged process involving an Advisory Committee and key stakeholder interviews. Prior to initiating these processes the Department's Biomonitoring Planning Project team (inside front cover) developed a vision statement (Attachment 1) to facilitate a common understanding of biomonitoring and provide a context for Advisory Committee members and key stakeholders.

Advisory Committee Process

1. Department personnel developed an initial list of biomonitoring needs to serve as a basis for the Advisory Committee process. The approach for identifying needs focused on uses of biomonitoring that could impact public health practice or policies in Washington. To do this, Department staff searched for instances where biomonitoring information would have been useful for making public health decisions. To identify these instances, they examined the published literature, state and local agency publications, and ongoing projects within the state. They

also interviewed a limited number of key informants and prospective Advisory Committee members.

2. For each biomonitoring need identified in Step 1, Department personnel developed an "application" describing the general background and need for biomonitoring; methods for obtaining biological samples and related information; how the data would be used; and other considerations, such as relevant federal or local approaches and potential difficulties recruiting people to provide biological samples.
3. Concurrent with the development of an initial list of biomonitoring needs, the Department convened an Advisory Committee. Department staff and a limited number of key informants identified prospective Advisory Committee members from academia, state and local health agencies, the state environmental agency (Washington State Department of Ecology), and a non-governmental environmental organization (Attachment 2). Advisory Committee members were asked to participate in two meetings to work with Department staff in identifying and prioritizing biomonitoring needs for the state.
4. The first Advisory Committee meeting focused on developing a process and criteria for use in prioritizing biomonitoring needs. The Advisory Committee used criteria from the CDC National Report on Human Exposure to Environmental Chemicals and the California Needs Assessment Report to the Biomonitoring Planning Project's Advisory Committee (California Department of Health Services, Oct. 28, 2002) as a starting point for discussion.
5. The second Advisory Committee meeting consisted of applying the criteria to the list of applications developed in Step 2. Advisory Committee members used the criteria to classify each application as a high, medium or low priority. The Advisory Committee discussed their individually developed priorities, proposed additional applications and came to a consensus on a final set of priorities.
6. Department staff completed a final document containing all applications describing biomonitoring needs including additional applications proposed and prioritized by the Advisory Committee.

Key Stakeholder Interview Process

1. Department personnel identified initial key stakeholders and developed an interview script for three groups of stakeholders including science and technology (science), policy makers and program managers (policy), and community representatives (Attachment 3).
2. An independent consultant, an environmental epidemiologist formerly employed by the University of Washington, contacted and sent materials to the initial list of stakeholders, conducted the initial interviews by telephone, and identified subsequent interviewees using snowball techniques.
3. The consultant synthesized the material, prepared a written report, and discussed findings with Department personnel.

Cost Estimates

In addition to these processes focusing on the need for biomonitoring in Washington State, the Department's Public Health Laboratory estimated the costs of developing laboratory capacity for analyzing biological samples for the applications described in Step 2 of the Advisory Committee process (start-up costs), and the costs associated with carrying out each biomonitoring application. Start-up costs included equipment, training of laboratory personnel, and supplies and laboratory personnel needed to support regular analysis of the chemical to be monitored. Yearly implementation costs were calculated as the costs of personnel, supplies, and equipment maintenance needed to analyze the expected number of samples for each application.

The Department's Office of Environmental Health Assessment estimated the field operational costs for each application. Start-up field costs included development of protocols, forms, institutional review board review, pre-testing and recruitment procedures. Field implementation costs included costs for recruiting, data collection, and data processing. Costs associated with outreach to the community were not included, as these costs will vary considerably depending on the specific community, the type of study, and the specific type of biomonitoring proposed.

The Office of Environmental Health Assessment combined the cost estimates from the Public Health Laboratory with their estimates to develop total start-up (year one) and implementation (subsequent years) costs for each application independently. These cost estimates are not precise and will vary substantially depending on the exact type of analysis, the number of samples to be processed, the type and location of the study population(s), and the sampling strategy. However, these costs were estimated using similar assumptions, allowing the Advisory Committee to compare cost estimates based on the same underlying assumptions.

The Office of Environmental Health Assessment also developed a spreadsheet, which calculated the marginal costs of adding another application given that a set of applications had already been selected. This was done to facilitate discussion among the Advisory Group and highlight to potential savings from the use of the same lab equipment or the same population for biomonitoring more than one chemical.

Results

Advisory Group Priorities

The initial set of biomonitoring applications included monitoring:

- Body burdens of selected substances in the general populations through statewide survey modeled on the National Health and Nutrition Examination Survey, including:
    - Urinary arsenic and cotinine.
    - DDT, dioxins, lead, polybrominated diphenyl ethers (PBDE), and polychlorinated biphenyls (PCB) in blood.
    - Mercury in blood, urine and/or hair.
- Body burdens in populations that consume large amounts of fish including:
    - DDT in breast milk of women eating fish high in DDT.

    - DDT, dioxins, PBDEs and PCBs in blood and mercury in the hair of Asian and Pacific Islanders and Native Americans.
    - Mercury in the hair of high consumers of canned tuna and recreational fishermen.
- Arsenic over time among individuals with known exposures to arsenic.
- The effectiveness of prevention actions, including:
    - Follow-up testing of children with elevated blood lead levels.
    - Methamphetamine in workers who clean up drug labs and in children who lived in homes serving as drug labs.
- Cholinesterase levels among pesticide applicators.
- Trihalomethanes among those who drink chlorinated drinking water and swim in chlorinated pools.

As result of discussion of biomonitoring needs in Washington State, the Advisory Committee added four applications to be included in the prioritization process:

- Urinary organophosphate pesticide metabolites in children through a statewide survey modeled on the National Health and Nutrition Examination Survey.
- Urinary organophosphate pesticide metabolites in agricultural workers.
- Lipophilic contaminants in the breast milk of nursing women.
- Emergent issues.

Attachment 4 provides a description of the initial and additional applications.

The criteria used to prioritize applications as high, medium or low included relatively higher priority for exposures to chemicals that:

- Are persistent or increasing.
- Show a strong association with a health effect.
- Result in serious health effects.
- Affect a relatively large proportion of the general population.
- Have been shown to be elevated in specific populations.
- Show toxicity in animal or human studies.
- Are recently recognized to be of potential concern.
- Can be used to assess the efficacy of public health actions to reduce exposure.
- Would be expected to result in a public health benefit.

These criteria were not weighted, although individual Committee members may have placed differential value on each criterion.

Additional criteria used during the Advisory Committee consensus process included giving higher priority to exposures to chemicals that:

- Affect vulnerable groups or specific racial and ethnic population groups.
- Are involuntary exposures.
- Have existing analytic methods to measure the chemical or its metabolite.
- Represent a small, incremental analytical cost to perform analyses.

These criteria were selected to obviate some of the major limitations of biomonitoring. Most importantly, these criteria place a lower value on obtaining measures that are difficult to interpret. Recent advances in biomonitoring allow us to measure substances in the human body, but we do not always know the health implications of such measurements. Thus, in some instances, it can be difficult to distinguish harmful exposures from those that do not cause harm. This is especially true for levels of exposure that do not cause immediate health effects, but rather represent low-dose exposures that may occur over many years or occur over shorter periods of time, but persist in the human body and may be contributing causes of chronic disease. Biomonitoring data are also difficult to interpret when we have no information about levels of a substance in comparison populations.

The final set of top priorities in rank order beginning with the highest priority are:

1. Monitoring breast milk for lipophilic compounds.
2. Conducting a statewide survey modeled on the National Health and Nutrition Examination Survey (DOH HANES) for mercury in blood, urine and/or hair.
3. Monitoring urinary arsenic levels in individuals with known exposures to arsenic.
4. Monitoring children for urinary organophosphate pesticide metabolites.
5. Monitoring mercury in the hair of Asian and Pacific Islanders.
6. Monitoring mercury in the hair of American Indians.
7. DOH HANES for urinary cotinine.
8. Monitoring agricultural workers for urinary organophosphate pesticide metabolites.
9. Cholinesterase monitoring of pesticide applicators.
10. Emergent issues.

Lead was specifically discussed as important, but was not included in the final list of priorities, because the Department and Washington State Labor and Industries already have programs for childhood and adult lead poisoning prevention, respectively. These programs include screening for elevated blood lead level and follow-up to assure appropriate medical treatment and environmental assessment and remediation.

Key Stakeholder Findings and the Relationship to the Advisory Committee's Recommendations

The consultant obtained information from six stakeholders in the science group, eight in the policy group, and nine from community based organizations. Twenty-one interviews were conducted by phone and two respondents completed the questionnaire that was included in the mailed materials and returned it to the consultant. Attachment 5 provides the consultant's final report.

Stakeholders were asked open-ended questions about which health conditions are of greatest concern in Washington. Interpreting the findings from this question is somewhat difficult because the relative frequency of conditions depends, in part, on how items are grouped (e.g., grouping lead, mercury and arsenic as heavy metals gives a relatively stronger weighting to this category than if each substance is considered separately); the responses represent a mixture of health outcomes and substances; the question was not

focused specifically on health conditions for which biomonitoring might be appropriate; and the number of total respondents is relatively small.

The most frequently expressed concern was neurological development, mentioned by 12 key stakeholders. Of the issues raised by the stakeholders, arsenic and hepatitis were mentioned least frequently, with one respondent each.

In general, there is considerable overlap between the issues of concern to the key stakeholders and the priorities of the Advisory Committee:

- Three of the Advisory Committee's priorities included mercury. While only six stakeholders mentioned mercury directly, 12 mentioned neurological development, which can be impaired by exposure to mercury.
- Cancer, asthma, smoking, cardiovascular disease, and respiratory problems are associated with smoking and exposure to environmental tobacco smoke. The stakeholders expressed concern about these issues relatively frequently (three stakeholders were concerned about respiratory disease and seven to ten respondents expressed concern about the other issues). These issues are consistent with the Advisory Committee's priority related to urinary cotinine, although it is likely that at least some of the stakeholders raised these issues in relation to ambient or indoor air hazards overall, not limited to tobacco.
- Seven of the stakeholders mentioned pesticides. Three of the Advisory Committee's priorities specifically refer to pesticides and pesticides form a portion of the lipophilic compounds in breast milk.
- The stakeholders expressed little concern about arsenic, one of the priorities of the Advisory Committee. However, arsenic has been associated with cardiovascular disease and some types of cancer, both of which the stakeholders mentioned as important issues.

In a related question, the policy and science groups were asked to rate specific substances as high, medium or low priority for biomonitoring. Mercury, lead, arsenic and pesticides received the highest ratings. These ratings are consistent with the Advisory Committee's priorities.

In response to how should we prioritize various uses of biomonitoring data, the stakeholders gave average ratings of medium to high for:

- Estimating the magnitude of a problem.
- Tracking trends.
- Identifying high-risk groups.
- Identifying modifiable risk factors.
- The availability of a public health action for intervention.

They gave an average rating of medium for:

- Etiologic studies.
- Assessing the effectiveness of interventions.

While the wording of the criteria rated by the stakeholders differed from that used by the Advisory Committee, there was a substantial amount of overlap. For example, tracking trends overlaps with the Advisory Committee's criterion of being persistent or increasing, estimating the magnitude of the problem overlaps with affecting a relatively large proportion of the general population, and identifying high-risk groups is consistent with the being elevated in specific populations. None of the criteria used by the Advisory Committee was rated as unimportant by the stakeholders. Etiologic study was the only criterion rated medium by the stakeholders and not included in the criteria developed by the Advisory Committee. The average rating for etiologic studies was the lowest of all the criteria the stakeholders were asked to rate.

In a question related to both priorities and to specific exposures or health conditions of concern, the stakeholders were asked to describe the three most important issues if funding required us to limit what we do. Major themes in both the policy and community groups included a focus on children, which is consistent with the Advisory Committee's priorities of monitoring breast milk and urinary organophosphate pesticide metabolites in children. The community group also recommended focusing on "high yield" situations defined as "bioaccumulating toxins, high-exposure and high-risk groups, growing exposures and well-known wide exposures." The policy group recommended focusing on issues where there was an opportunity to have an impact. Both of these recommendations are consistent with the Advisory Committee's criteria for setting priorities. The science group agreed with focusing on where exposures are likely to be high but also wanted more of an emphasis on research.

The policy and community groups provided guidance to the Department in terms of interacting with communities (e.g., partnering, education, clear language, follow-up). The policy group also recommended the use of convenience samples where feasible. In a related question on whether most people would trust the Department to collect biological samples, the community stakeholders thought that trust needs to be built and the policy group thought that communities would need to be educated around issues and solutions. Half of the science stakeholders thought that the Department is already trusted to do this type of work, indicating differing perspectives between the science and other groups.

The policy and science groups were asked about whether specific population subgroups were defined too broadly or too narrowly. Subgroups that overlap with the final priorities of the Advisory Committee included Tribal and Asian fish consumers, farmers using pesticides and children. Most stakeholders thought the Tribal and Asian fish consumers were appropriate subgroups, and among those who disagreed, some thought these categories were too broad and others thought they were too narrow. The policy stakeholders thought that "farmers using pesticides" was too broad and should be limited to specific job categories or those with direct exposures; the science group was divided on this issue. The Advisory Committee's priority for cholinesterase monitoring of pesticide applicators is very specific and, therefore, addresses the policy groups' concern. The Advisory Committee's priority of monitoring agricultural workers for urinary organophosphate pesticide metabolites most likely does not provide the specificity

recommended by the policy group. Most stakeholders thought the category of children was appropriate, although some thought it was too broad.

The policy and science stakeholder groups were asked whether they thought there were any specific biomonitoring ideas that would be politically infeasible. Five stakeholders did not think there were political barriers. Of those who thought there were barriers, the most common theme was concern for opposition from manufacturers and business owners to biomonitoring for exposures related to their businesses, including occupational exposures and exposures from recreational activities, such as fishing.

The science and policy stakeholders were also asked about collecting exposure data at the same time as biological samples are collected. The majority of stakeholders supported the collection of exposure information.

Cost Analyses

Attachment 6 includes two tables of cost estimates for each biomonitoring application. Table 1 contains the full start-up (year one) and implementation (subsequent years) costs. Total start-up costs ranged from $160,000 to $860,000. The higher costs were associated with applications that require the purchase and operation of a high resolution GC/MS or a HPLC/MS/MS. Yearly operational costs ranged from $215,000 to $850,000 per year. The highest cost applications were those using a state-HANES type study design where a random sample of approximately 1,000 individuals from across the state would be selected.

Table 2 contains costs and marginal costs of the top 10 applications as prioritized by the Advisory Committee. There are some clear economies of scale when the same equipment is used for more than one application, or when the same population is used to study exposure to more than one chemical.

Summary and Conclusions

There was a high degree of concurrence between the Advisory Committee and the key stakeholders regarding:

- Important concerns and issues.
- Criteria for selecting priorities used by the Advisory Committee and stakeholders' ratings of how we should select priorities.
- Subpopulations identified by the Advisory Committee and general agreement by the stakeholders that the subpopulation definitions were appropriate.

Given this concurrence, the Department has adopted the priorities established by the Advisory Committee as a focus for biomonitoring activities in Washington. Given the concern of the policy group that "farmers using pesticides" is too broad a category, the Advisory Committee's priority related to agricultural workers may need additional consideration before implementation.

In implementing the Advisory Committee's priority applications, the Department recognizes the importance of heeding the advice of the policy and community stakeholder

groups regarding the need for partnering with communities; using clear, non-technical language when communicating with communities; building trust between communities and the Department; and educating communities about issues related to biomonitoring. Those engaged in biomonitoring may need to be particularly aware of how biomonitoring might affect different sectors of the economy.

The Department also recognizes the need to balance the costs of implementing specific priorities, the interests of communities that might place a higher or lower priority on any specific application, and the availability of money for specific applications in making decisions about implementation. The Department views the approach of selecting a relatively lower priority over a higher priority based on feasibility of implementation as consistent with the general direction provided by the Advisory Committee.

This plan proposes priorities for biomonitoring. Implementing any of these priorities requires additional planning for issues such as developing protocols for sample collection, transportation, storage and laboratory analysis; estimating sample size and determining recruitment methods; resolving data issues such as data handling, analysis and dissemination; and assuring privacy protections. Because each of these issues depends on the analyte and the sampling frame, specification on how to implement each of the applications is beyond the scope of this plan.

Attachment 1: Vision Statement

Biomonitoring Planning Project Vision Statement

What is biomonitoring and how is it used to improve and protect public health?

Biomonitoring focuses on the presence of environmental chemicals in the human body. In this project, the term "biomonitoring" refers to the assessment of people's exposure to toxic substances through the laboratory measurement of these substances or their metabolites in human specimens. Specifically, biomonitoring is done on blood, urine, serum, saliva, or tissue samples. Biomonitoring can assess exposure of a single person or by aggregating data on many people, a population. Biomonitoring measurements complement environmental measurements of toxic substances in air, water, food, soil and dust. The results of biomonitoring are used to help make decisions about protecting people from various deleterious health outcomes – such as environmental diseases, birth defects, disabilities, or death – thought to be related to toxic over-exposure. Public health policy-makers and program managers can use these data to find out whether a substance is causing a health problem, to determine how to treat the problem, and to plan how to prevent exposure in the future.

Specific purposes of biomonitoring measurements in public health include:

- To measure the prevalence of elevated levels of toxic substances in a population group (e.g., the prevalence of blood lead levels ≥ 10 µg/dL in children living in an inner-city environment).
- To determine levels of exposure in population groups who may be at increased risk of exposure.
- To provide information on levels of human exposure for studies examining the relationship between exposure to a toxic substance (or toxic substances) and adverse health effects.
- To determine whether levels of toxic substances are higher in potentially more vulnerable population groups such as children, the elderly, or women of childbearing age than in the general population.
- To track over time, trends in the levels of exposure of a population group to specific toxic substances (e.g., mercury levels in a fish-consuming population).
- To assess the effectiveness of public health efforts to reduce the exposure of specific populations to toxic substances.

CDC grant program for building state capacity for biomonitoring

Programs in environmental health are focused on finding ways to reduce morbidity and mortality resulting from exposure to hazardous substances. Recent advances in the techniques to measure markers of exposure to environmental toxicants in humans are changing the ways in which environmental scientists, epidemiologists, and policy-makers characterize and interpret such exposure. A year ago, the Centers for Disease Control & Prevention (CDC) initiated a grant program to promote planning for the development, implementation, and expansion of state-based biomonitoring programs to help prevent disease resulting from exposure to toxic substances. The program addresses the importance of building public health laboratory capacities for performing measurements and analyses that are accurate, precise, sensitive, specific and have adequate throughput in a timely manner.

During the first two years of the project, the CDC Biomonitoring grant program focuses on assessment of the need for biomonitoring within the state, and development of a plan for

implementing and expanding biomonitoring capacity to meet these needs. To effectively develop these plans, state public health laboratories must interface and actively collaborate with other public health partners, including epidemiologists, environmental health specialists, physicians, communities, academic centers, and other health professionals at state and local levels. In addition, collaboration with other state public health laboratories is advantageous to address the regional biomonitoring issues.

For more information about the concept of biomonitoring and the CDC Biomonitoring Program see references at the website: http://www.cdc.gov/nceh/dis/biomonitorong.htm

Biomonitoring grant planning project in the State of Washington DOH

Washington State Department of Health (DOH) Public Health Laboratories (PHL) process for developing a plan to assess the state needs for biomonitoring consists of the following steps:

1. Identification of specific environmental exposures within the state that may have a negative impact on the health of individuals or communities.
2. Review of current and past DOH environmental health programs where better biomonitoring and exposure data could have contributed to better policy or program decisions.
3. Identification of key biomonitoring and exposure assessment projects.
4. Prioritization of these projects, based on expected public health impact.
5. Estimation of the cost of developing laboratory capacity for performing biomonitoring measurements for priority projects.
6. Estimation of the operational cost of conducting biomonitoring measurements.
7. Development of the institutional partnership agreements to effectively implement the biomonitoring program.
8. Development of a biomonitoring plan to complete the priority projects.

At the conclusion of the planning process, DOH will submit a proposal to the CDC National Center for Environmental Health, asking for implementation grant funds to establish a biomonitoring program at the PHL.

A paradigm for biomonitoring

Episodic exposure assessment studies in defined population. Biomonitoring at a state health agency is optimally composed of both continuous and episodic measurement of biomarkers of exposure to environmental chemicals and/or of early biological effects from environmental exposures. *Episodic biomonitoring* has two distinct contexts, both aimed at determining if exposure to environmental chemicals has occurred:

- In the first, there is a known or suspected environmental hazard, but it is not known whether any specific environmental chemicals have accumulated in human tissue.
    - Early detection of possible chemical terrorist attack represents an example of a high-priority application of this context. Presently, state public health laboratories are being equipped in order to be capable of rapid response to bioterrorism events. However, state public health laboratories have limited capacity to handle events of chemical terrorism. Preparing DOH PHL to perform biomonitoring measurements will provide needed capacity and infrastructure to begin addressing needed responses to chemical terrorism.
- In the second, there is a possible cluster of cases of "environmental disease," but it is not known whether any specific environmental chemicals might be implicated.

Continuous monitoring of the entire population statewide. The objective of continuous biomonitoring is to track exposure levels to specific environmental chemicals in the general population, as well as to find cases of elevated exposures, which represent levels of immediate public health concern. Three mechanisms are envisioned for this continuous monitoring:

- *Electronic laboratory reporting via WEDSS*. State law (WAC 246-101) requires labs to report lead exposure blood-test results to DOH within two workdays. Farm-worker exposure to organophosphate pesticides can be monitored by tracking levels of the enzyme cholinesterase. Toxic exposures to carbon monoxide can be monitored by reporting to DOH of elevated carboxyhemoglobin levels. Toxic exposures to nitrates can be monitored by reporting of elevated methemoglobin levels. External laboratory reporting to DOH of elevated levels of specific analytes will occur electronically via the Washington Electronic Disease Surveillance System (WEDSS) for conditions included under state mandatory reporting regulations. PHL test results will also be sent electronically to WEDSS. Automated alerts will be generated when test results exceed pre-defined thresholds, and public health practitioners in local and state health agencies can also obtain routine data electronically via WEDSS.
- *Annual State Report on Human Exposure to Environmental Chemicals*. Modeled after the CDC National Health & Nutrition Examination Survey (N-HANES), the state HANES can provide the framework for routine on-going assessment of exposure to environmental chemicals in the general population. The state HANES will utilize mobile vans to gather population-based "baseline" data at randomly chosen sites statewide, with PHL testing for substances such as As, Cd, Hg, PBBs, PCBs, Pb, and pesticides. Environmental epidemiology staff, located within PHL, will prepare an annual report based on these continuously collected data.
- *Convenience sampling*. The second use of samples collected for another purpose is termed " convenience" sampling. These samples may not represent a truly random cross-section of the population, but tracking the levels of biomarkers for environmental chemicals in human tissue in this fashion can provide important clues. This form of "sentinel surveillance" may function as an early warning system, especially if it is used to target vulnerable population groups. Examples of convenience samples include: discarded blood from routine blood tests; discarded urine from routine urine tests; placental tissue; tissue samples collected during surgical procedures; tissue samples collected during routine autopsy. Testing protocols at PHL will resemble those used for the state HANES. Environmental epidemiology staff, located within PHL, will prepare an annual report based on these continuously collected data.

Attachment 2: Advisory Committee Members

Advisory Committee

Philip Dickey, PhD	Staff Scientist, Washington Toxics Coalition
Romesh Gautom, MS PhD	Director, Public Health Laboratory, Washington State Department of Health
Maxine Hayes, MD, MPH	State Health Officer, Washington State Department of Health
David A. Kalman, PhD	Chair and Professor, Department of Environmental and Occupational Health Sciences, School of Public Health & Community Medicine, University of Washington
Matthew C. Keifer, MD, MPH	Associate Professor, Department of Environmental and Occupational Health Sciences, School of Public Health & Community Medicine, University of Washington
Craig McCormack, PhD	Toxicologist, Toxics Cleanup Program, Washington State Department of Ecology
Ngozi Oleru, PhD	Director, Environmental Health Division, Public Health - Seattle & King County
Juliet VanEenwyk, PhD	State Epidemiologist for Non-Infectious Conditions, Office of Epidemiology, Washington State Department of Health
Jim O. White, BS	Acting Assistant Secretary for Environmental Health, Washington State Department of Health

Washington Department of Health Staff

James VanDerslice, PhD	Environmental Health Assessments
Steven Macdonald, PhD	Non-Infectious Conditions Epidemiology
Denise Laflamme, MS	Environmental Health Assessments
Harold Ruark, MS	Public Health Laboratory
Pamela Navaja, BS	Public Health Laboratory
Marina Silverstone, MS	Public Health Laboratory

Attachment 3: Key Stakeholders

Science & technology group

David Eaton PhD. Professor, Department of Environmental & Occupational Health Sciences, and Associate Dean for Research, School of Public Health & Community Medicine, University of Washington.

Joel Kaufman MD, MPH. Associate Professor, Department of Environmental & Occupational Health Sciences, Adjunct Associate Professor, Department of Epidemiology, and Director, Occupational & Environmental Medicine, School of Public Health & Community Medicine; Associate Professor, Department of Medicine, University of Washington.

John Kissel PhD. Associate Professor, Department of Environmental & Occupational Health Sciences and Director, Environmental Health Technology, School of Public Health & Community Medicine, University of Washington.

Thomas Martin MD, MPH. Associate Professor, Department of Medicine, and Director, Emergency Medicine Toxicology Service, School of Medicine, University of Washington.

Tim Takaro MD. Clinical Assistant Professor, Occupational & Environment Medicine Program, Department of Environmental & Occupational Health Sciences, School of Public Health & Community Medicine, University of Washington.

Charles Timchalk PhD. Staff Scientist, Pacific Northwest National Laboratory.

Policy-makers and program managers

David Bonauto MD, MPH. Safety & Health Assessment & Research for Prevention, Washington State Department of Labor & Industries.

Robert Duff MS. Manager, Site Assessment Section, Office of Environmental Health Assessment, Washington State Department of Health.

Mike Gallagher BS, MS, MPA. Mercury Coordinator, Washington State Department of Ecology.

Maxine Hayes MD. State Health Officer, Washington State Department of Health.

Beth Mueller DrPH. Professor, Department of Epidemiology, School of Public Health & Community Medicine, University of Washington, and Faculty Member, Fred Hutchinson Cancer Research Center.

Carl Osaki RS, MSPH. Member, Washington State Board of Health.

Mary Salazar EdD. Professor, Department of Psychosocial & Community Health, and Director, Occupational Health Nursing, School of Nursing, University of Washington.

Marianne Seifert MA. Health Policy Advisor, Washington State Board of Health.

Community Representatives

Carlos Diaz. Chief Executive Officer, Washington State Migrant Council.

Ricardo Garcia BA. Executive Director/General Manager, Radio KDNA, Yakima.

Pam Johnson. Field Director, People for Puget Sound.

Tanya Kim. Use Program Manager, International District Housing Alliance.

Elise Miller MEd. Executive Director, Institute for Children's Environmental Health.

Ivy Sager-Rosenthal. Environmental Advocate, WashPIRG.

Patti Stone. Environmental Planner, Colville Confederated Tribes.

Skip Vaughn. President, South Tacoma Neighborhood Association.

Clark Williams-Derry, BA. Research Director, Northwest Environment Watch.

Biomonitoring Applications

CDC Biomonitoring Planning Grant
Revised based on Advisory Committee Meeting, March 17, 2003

Washington State Department of Health
June 16, 2003

Table of Contents

Overview of Applications

The purpose of this overview is to give an introduction to the biomonitoring applications and describe the commonalities between them. Overall these applications can be grouped into five general categories.

1. Body burdens in the general population

A large number of the applications are designed to gather body burden data from a representative sample of the general population. We envision a study, which is modeled after the Health and Nutrition Examination Survey (HANES), administered by the National Center for Health Statistics (www.cdc.gov/nchs/nhanes.htm). The focus of the national effort has not been environmental health and only a few biomarkers have been incorporated (e.g. lead).

In this packet, you will find biomonitoring applications using a state-based HANES covering several specific contaminants, including: PCBs, DDT, dioxins, PBDEs, arsenic, mercury, lead, organophosphate metabolites, and cotinine (a marker of tobacco smoke exposure). We have developed separate biomonitoring applications for each of these contaminants as they vary in the levels of environmental contamination, in their health effects, and in how much is known about their health effects.

While there are many possible sampling schemes, the goal is to estimate the body burden among a representative sample. It is also possible to over-sample specific groups to be able to derive estimates of body burden among specific racial or ethnic groups, or for groups living in different locations or regions of the state.

Typically, the subjects are also administered a detailed questionnaire covering demographics, lifestyle, diet, occupation, etc. We envision including specific questions regarding behaviors that lead to exposure (e.g., frequency and amount of fish consumption). From our perspective, there are several valuable outcomes from having such population-based data. These include:

A. Compare the distribution of body burdens in Washington State to national data recently developed by CDC.

B. Identify trends over time.

C. Identify high-risk ethnic, racial and/or regional populations to focus prevention efforts.

D. Examine the relationship between behaviors or other risk factors that are associated with exposure (e.g. amount, frequency and/or species of fish consumed) and body burden. This will assist in planning and evaluating prevention efforts.

E. Validate the use of questionnaires and other less invasive techniques as measures estimating exposure.

F. Conduct ecologic studies of the relationship between sub-population body burdens and the frequency of disease in these sub-populations. Such studies are useful for generating hypotheses about cause-effect relationships.

2. Body burdens in specific populations which consume large amounts of fish

While over-sampling in a state-based HANES would allow estimates of body burdens in a specific sub-group, there are a number of applications which focus solely on high-risk populations based on their unique diets. Many of the persistent, bioaccumulative toxins are found at very high levels in fish. Parts of the American Indian and Asian and Pacific Islander communities consume fish far more frequently than the rest of the state. As such, there are applications which focus on estimating the body burden of several contaminants (i.e. PCBs, DDT, dioxins, PBDEs, mercury) in these two populations.

Another at-risk group is people who consume large amounts of tuna (mercury exposure). This may include women and children enrolled in the WIC program (a supplemental nutrition program). We also propose examining the levels of lipophilic compounds and specifically DDT (and metabolites) in the breast milk of women who may be exposed to these compounds from eating fish.

3. Body burdens over time

One application is a longitudinal study to better understand the determinants of arsenic body burden by conducting a longitudinal study of urinary arsenic levels and observations of potential exposure in the diet and via other sources.

4. Effectiveness of prevention actions

A study is proposed to assess the effectiveness of lead prevention efforts by conducting a series of follow-up blood lead tests after a child with a blood lead level above the action limit has been identified, and steps have (hopefully) been taken to identify and remove the source(s) of lead in the child's environment.

Another potential application would assess the effectiveness of efforts to clean-up clandestine drug labs by monitoring workers who are responsible for cleaning up drug labs and monitoring children who live in the remediated homes for levels of methamphetamine.

5. Significance of known exposures in specific populations

Three applications seek to estimate the significance of exposure in populations with known exposures. The first would provide support for baseline and ongoing cholinesterase monitoring for pesticide applicators. The second would provide ongoing monitoring of all pesticide workers for organophosphate metabolites. The third would assess exposure to THM (a byproduct of water disinfection using chlorine) among people who drink chlorinated water supplies, and among women who use pools or spas.

6. Emerging issues

One application is devoted to having resources available to address emerging biomonitoring issues and to use new biomonitoring tools.

Body Burdens in the General Population

Biomonitoring Application Application Number: 1

Title: **DOH Health & Nutrition Examination Survey (HANES) for urinary arsenic.**

Aims

To characterize the distribution of urinary arsenic levels in a sample of the general population in Washington State.

Background and Needs

Many Washington residents may be exposed to greater than normal amounts of arsenic in their water and soil. Of particular interest in Washington is the widespread contamination of soil due to past emissions of arsenic from the Tacoma and Everett Smelters (estimated at about 450,000 acres) and past use of lead arsenate pesticide (estimated at about 188,000 acres) (Area-Wide Soil Contamination Task Force, 2003). Although smelter emissions and pesticide use no longer contribute arsenic to the environment, past contamination from these sources will remain in surface soils for centuries where it can be an ongoing source of exposure to current and future residents.

Urinary arsenic levels have been used to determine people's exposure to arsenic in soil. However, background concentrations of urinary arsenic have not been well established. Background urinary arsenic concentrations are important for evaluating the significance of urinary arsenic data collected from people with known or expected exposures to arsenic in the environment. People with long-term exposure to environmental arsenic have increased risk of developing a wide variety of health problems including cardiovascular disease, diabetes mellitus, numerous skin problems, and several forms of cancer (ATSDR, 2000).

Methods

- Conduct ongoing testing of urinary arsenic in a sample of the general public. This sampling effort would be similar to the CDC's National Health and Nutrition Examination Survey (NHANES). This testing would provide "baseline" levels of urinary arsenic for the general public in Washington State.
- Summarize the results of urinary arsenic testing annually.
- Collect concurrent questionnaire information on diet and other possible exposures.

Use of Data

This data would provide state specific exposure distributions of arsenic in urine, which could potentially be used to monitor trends over time, identify high-risk populations, and occupational or behavioral risk factors for elevated urinary arsenic (if urine samples are paired with a dietary or occupational exposure questionnaire).

Other Considerations

Urinary arsenic is not one of the environmental chemicals currently included in national biomonitoring efforts by CDC (CDC, 2003). Therefore, national comparison values will not be available.

References

ATSDR, 2000. Toxicological Profile for Arsenic.

Area-Wide Soil Contamination Task Force, 2003. Preliminary estimates of acres affected by various sources of arsenic. Personnel communication Jim W. White, DOH.

CDC, 2003. Second National Report on Human Exposure to Environmental Chemicals. Available on the web at: http://www.cdc.gov/exposurereport/

Biomonitoring Application Application Number: 2

Title: **DOH Health & Nutrition Examination Survey (HANES) for cotinine.**

Aims

To characterize the distribution of blood serum cotinine levels in a sample of the general population of adults and/or children in Washington State.

Background and Needs

Tobacco use is a leading cause of preventable death, and is associated with one in five of all deaths (DOH, 2002A). Exposure to environmental tobacco smoke (ETS) is associated with a variety of health effects including low birthweight of babies whose mothers' smoke, respiratory illness and middle ear infections in children, and lung cancer, and heart disease in adults. In 2000, smoking was allowing in an estimated 19.6% of all Washington households during the past month and in 57.0% of households where smokers lived. Another Washington State survey conducted in 2000 indicated that 62.1% of sixth graders had been in a room with someone who was smoking at least once during the past week (DOH, 2002B).

Information on tobacco use and exposure to environmental tobacco smoke (ETS) is collected by surveying people about their use and exposures around the home. However, reliability of survey information is unknown. Cotinine is a metabolite of nicotine and is a biomarker of exposure to ETS that can be used to assess exposure to cigarette smoke in both smokers and nonsmokers. A recent CDC-NHANES report provides data on cotinine levels found in the general U.S. population from 1999 - 2000 (CDC, 2003).

Methods

- Conduct ongoing or annual testing of cotinine in blood from a sample of people from the general public. This sampling effort would be similar to the CDC's National Health and Nutrition Examination Survey (NHANES). This testing would provide "baseline" levels of blood cotinine for the general public in Washington State.
- Summarize the results of blood cotinine testing annually.
- Collect concurrent questionnaire information on smoking and ETS exposures.

Use of Data

To evaluate the extent to which statewide policies that restrict exposure to ETS in the workplace have been effective in reducing exposure for non-smokers. To evaluate the extent to which the Washington State tobacco prevention and control program's efforts have reduced, and continue to reduce, exposure to ETS among the general population of non-smokers. Compare survey information to biomarker data in order to assess reliability of surveys.

Other Considerations

Washington State is launching a statewide media campaign to increase awareness of the health hazards of secondhand smoke exposure. A coordinated effort among communities

to increase smoking bans in public areas, currently exempted worksites, and homes, is launching in tandem with the media campaign. If these efforts are effective, we would expect to see measurable changes in exposure within 2-5 years.

References

DOH, 2002A. The Health of Washington State. Chapter on Tobacco Use and Exposure. Available on the web at: http://www.doh.wa.gov/HWS/default.htm

DOH, 2002B. The Health of Washington State. Chapter on Indoor Air Quality.

CDC, 2003. Second National Report on Human Exposure to Environmental Chemicals. Available on the web at: http://www.cdc.gov/exposurereport/

Biomonitoring Application Application Number: 3

Title: **DOH Health & Nutrition Examination Survey (HANES) for DDT in blood.**

Aims

To characterize the distribution the levels of DDT and its metabolites in blood from a sample of the general population in Washington State.

Background and Needs

The pesticide DDT was widely used until it was banned in the early 1970's. Exposure to DDT is associated with developmental effects and cancer. DDT, and its metabolites DDE and DDE, are persistent in the environment and have been shown to accumulate in the fatty tissues of animals and people (ATSDR, 1994). Young children are at risk from exposures to DDT due to possible effects on the developing nervous system. DDT had been used extensively in Eastern Washington and elevated DDT levels have been found in Yakima River fish and in fish elsewhere in Washington (DOH, 1998; PSAMP, 2001; EPA, 2002; Tetra Tech Inc., 1996; Ecology, 2003).

Methods

- Collect and analyze blood samples for DDT from a sample of the general population of Washington State. Blood samples will be analyzed for DDT, DDE and DDD.
- Summarize the results of DDT blood testing annually.
- Collect concurrent questionnaire information on diet and other risk factors.

Use of Data

This data would provide state specific exposure distributions of DDT and its metabolites in blood, which could potentially be used to monitor trends over time, identify high-risk populations, and occupational or behavioral risk factors for elevated DDT levels (if blood samples were paired with a dietary or occupational exposure questionnaire).

Other Considerations

National data on DDT levels in blood will be collected by CDC, however Washington residents probably consume more fish than the general U.S. population and state specific levels would be helpful for comparison (CDC, 2003). General population samples could be analyzed for other biomarkers.

References

ATSDR, 1994. Toxicological Profile for 4,4'-DDT, 4,4'-DDE, 4,4'-DDD (update).

CDC, 2003. Second National Report on Human Exposure to Environmental Chemicals. Available on the web at: http://www.cdc.gov/exposurereport/

Puget Sound Ambient Monitoring Program (PSAMP), 2001. Toxic contaminants in marine and anadromous fishes from Puget Sound, Washington. Results of the Puget Sound Ambient Monitoring Program Fish Component, 1989-1999. Washington Dept. of Fish and Wildlife. Available at www.wa.gov/wdfw/fish/psamp/toxiccontaminants.htm.

Ecology, 2003. Unpublished data for fish sampled from the Okanogan and Walla Walla Rivers. Washington State Department of Ecology.

EPA, 2002. Columbia River Basin Fish Contaminant Survey, 1996-1998. EPA 910/R-02-006.

Tetra Tech, Inc., 1996. Assessing human health risks from chemically contaminated fish in the Lower Columbia River. Final Report. Prepared for the Columbia River Bi-State Program

DOH, 1998. DDT and DDE transmission through breast milk: Yakima River basin. Washington State Department of Health.

Biomonitoring Application Application Number: 4

Title: **DOH Health & Nutrition Examination Survey (HANES) for dioxins in blood.**

Aims

To characterize the distribution of dioxins blood levels in a sample of the general population in Washington State.

Background and Needs

Dioxins refer to a group of chemicals that were contaminants in some previously used pesticides and are formed during high temperature combustion. Dioxins are persistent environmental contaminants that build up in the fat of animals and people. Exposure to dioxins has been associated with developmental effects, impacts on the immune system, and cancer. Since dioxins accumulate in fatty tissues, meat and fish have been identified as common sources of dioxins exposures for people. Dioxins have been shown to be widespread in the fat and blood of the general population (ATSDR, 1998).

Methods

- Collect and analyze blood for dioxins from a sample of the general population of Washington State. Blood samples will be analyzed for individual dioxins congeners.
- Summarize the results of dioxins in blood testing annually.
- Collect concurrent questionnaire information on diet and other risk factors.

Use of Data

This data would provide state specific exposure distributions for dioxins in blood, which could potentially be used to monitor trends over time, identify high-risk populations, and occupational or behavioral risk factors for elevated dioxin levels (if blood samples were paired with a dietary exposure questionnaire).

Other Considerations

No national data on dioxin levels in blood in the general population are currently being collected. Washington residents may be at higher risk of exposure to dioxins from eating fish compared to other regions of the country. General population samples could be analyzed for other biomarkers. Background levels of dioxin exposures are thought to be at or near effects levels, so public health response would be unclear.

References

ATSDR, 1998. Toxicological Profile for Chlorinated Dibenzo-p-dioxins (update).

Biomonitoring Application Application Number: 5

Title: **DOH Health & Nutrition Examination Survey (HANES) for lead in blood.**

Aims

To characterize the distribution of blood lead levels in children in a sample of the general population of Washington State.

Background and Needs

Lead in gasoline, paint and solder in food cans had historically been significant sources of lead exposure, however lead has generally been eliminated from these products (ATSDR, 1993). Current sources of lead exposure include lead paint in older homes, some pottery and other imported products containing lead, traditional folk remedies from Mexico, and lead brought home associated with occupational exposures (DOH, 2002).

Lead is harmful to brain development and can cause learning and behavioral problems. Children are especially sensitive to the toxic effects of lead. Elevated blood lead levels are used to assess lead exposures and have been associated with the neuro-behavioral effects of lead. Children's blood lead levels have been decreasing in the general population (CDC, 2003). Currently, the CDC defines an elevated blood lead level in children as 10 ug/dL or above (CDC, 2003). A DOH study conducted in 1999 estimated the prevalence of elevated blood lead levels in 1 and 2 year olds at 0.9% for all children in the state and 3.8% in Hispanic children in central Washington (DOH, 2002).

Methods

- Conduct ongoing testing of blood leads of children in a sample of the general public. This sampling effort would be similar to the CDC's National Health and Nutrition Examination Survey (NHANES). This testing would provide "baseline" levels of blood lead for the general public in Washington State.
- Summarize the results of blood lead testing annually.
- Collect concurrent questionnaire information on risk factors.

Use of Data

Data would provide further information on prevalence of elevated blood levels in children. Data will be compared to national data from CDC to track prevalence of elevated blood lead levels over time. Testing could identify high-risk groups.

Other Considerations

While some information exists on the prevalence of elevated blood lead levels in children in Washington State, the additional cost of analyzing for lead is minimal if blood samples are being collected for testing other environmental chemicals.

References

ATSDR, 1993. Toxicological Profile for Lead

CDC, 2003. Second National Report on Human Exposure to Environmental Chemicals. Available on the web at: http://www.cdc.gov/exposurereport/

DOH, 2002. The Health of Washington State. Chapter titled Childhood Lead Poisoning. Available on the web at: http://www.doh.wa.gov/HWS/default.htm

Biomonitoring Application Application Number: 6

Title: **DOH Health & Nutrition Examination Survey (HANES) for mercury in blood, urine and/or hair.**

Aims

To characterize the distribution of blood, urine and/or hair mercury levels in the general population.

Background and Needs

There are several sources of exposures to mercury and people can be exposed to different forms of mercury. People can be exposed to methylmercury in their diets, especially from fish. Mercury levels in human hair and blood have been used to evaluate exposures to methylmercury via the diet (ATSDR, 1999). Mercury levels in blood reflect recent methylmercury exposures, while mercury levels in hair reflect longer-term exposures. Exposure to methylmercury can be especially harmful to the developing nervous systems of young children and fetuses (NAS, 2000). Levels of mercury in hair and blood in exposed populations have been associated with neuro-developmental effects.

People can be exposed to elemental mercury from having amalgam dental fillings since these fillings contain approximately 50% mercury. People can also be exposed to elemental mercury from contact with household products such as broken mercury containing thermometers. Urinary mercury has shown to be associated with exposures to elemental mercury. Urinary mercury levels have been linked to adverse neurological and renal health effects.

Background concentrations of mercury in blood, hair and urine in the general population have not been well defined. The CDC has begun ongoing biomonitoring of the general U.S. population for mercury in blood (CDC, 2003). Background blood, hair and urine concentrations are important for evaluating the significance of mercury levels in people potentially exposed to high levels of mercury. Background blood, hair and urine concentrations can also be used to evaluate changes in mercury exposures to the general population over time. Collecting background data for Washington state residents can be used to compare to national background concentrations. This may be important for identifying or evaluating exposures to mercury specific to Washington State. An example of this might include fishermen or other populations who eat locally caught fish known to contain higher levels of methylmercury.

Methods

- Conduct ongoing testing of blood, urine and/or hair for mercury in a sample of people from the general public. This sampling effort would be similar to the CDC's National Health and Nutrition Examination Survey (NHANES). This testing would provide background or "baseline" levels of blood, urine and/or hair mercury for the general public in Washington State.
- Summarize the results of mercury testing annually.
- Collect concurrent questionnaire information on diet and other risk factors.

Use of Data
These data would provide state specific exposure distributions of mercury in blood or hair, which could potentially be used to monitor trends over time or identify high risk populations. Data would also be used to validate questionnaire data.

Other Considerations
National data on mercury levels in blood are being collected by CDC, however Washington residents probably consume more fish than the general U.S. population and state specific levels would be helpful. General population samples could be analyzed for other biomarkers.

References
ATSDR, 1999. Toxicological Profile for Mercury.

CDC, 2003. Second National Report on Human Exposure to Environmental Chemicals. Available on the web at: http://www.cdc.gov/exposurereport/

NAS, 2000. Toxicological effects of methylmercury. National Academy of Sciences, National Research Council, National Academy Press.

Biomonitoring Application Application Number: 7

Title: **DOH Health & Nutrition Examination Survey (HANES) for PBDEs in blood.**

Aims

To characterize the distribution of PBDE blood levels in a sample of the general population in Washington State.

Background and Needs

Polybrominated diphenyl ethers (PBDEs) have been widely used as flame retardants in a variety of consumer products. Levels of PBDEs in the environment, including fish, have been increasing. PBDEs are lipophilic and are structurally similar to PCBs and DDT, which are known to persist in the environment. There have not been efforts to analyze fish in Washington State for PBDEs, although their presence in fish is expected.

Toxicity studies on PBDEs suggest possible thyroid effects, neurobehavioral effects, and cancer, however toxicity information on these chemicals is limited (McDonald, 2002; Branchi, 2002; ATSDR, 2002). PBDEs have been widely detected in human blood, breast milk and body fat samples.

Methods

- Collect and analyze blood for PBDEs from a sample of the general population of Washington State. Sample collection will be conducted annually or biannually.
- Summarize the results of PBDEs in blood testing annually or biannually.
- Collect concurrent questionnaire information on diet and other risk factors.

Use of Data

Data would be used to track the distribution of PBDEs in the general population over time. These data could also be used to identify high-risk populations if concurrent information is collected on dietary and occupational factors.

Other Considerations

It is unclear how information on PBDEs in the general public would be used towards controlling release of these substances due to their widespread use in consumer products. Since there is limited toxicity information on these compounds, it is unclear how levels in blood would be interpreted in terms of health risks or in terms of comparison values. Analytical methods are similar to PCBs and DDT.

References

ATSDR, 2002. Draft Toxicological Profile for PBBs and PBDEs.

MacDonald, 2002. A perspective on the potential health risks of PBDEs. Chemosphere, 46: 745-755.

Branchi, I., et al., 2002. Effects of perinatal exposure to a polybrominated diphenyl ether (PBDE 99) on mouse neurobehavioural development. Neurotoxicology, 23: 375-384.

Biomonitoring Application Application Number: 8

Title: **DOH Health & Nutrition Examination Survey (HANES) for PCBs in blood.**

Aims

To characterize the distribution of PCB blood levels in a sample of the general population in Washington State.

Background and Needs

Polychlorinated biphenyls (PCBs) are persistent environmental contaminants that were previously used as coolants and lubricants in transformers and other electrical equipment. PCBs do not break down quickly in the environment and as such they remain an ongoing source of human exposure. Since PCBs accumulate in fatty tissues, meat and fish have been identified as common sources of PCB exposures for people. PCBs have been shown to be widespread in the fat and blood of the general population. Studies have linked PCB levels in human blood with dietary intake of PCBs from fish. Studies have also linked PCB levels in blood of mothers and developmental effects on the nervous system of their children exposed in utero (ATSDR, 2000). Exposure to PCBs has been associated with impacts to the developing fetus, impacts on the immune system, and cancers.

Methods

- Collect and analyze blood for PCBs from a sample of the general population of Washington State. Blood samples will be analyzed for individual PCB congeners.
- Summarize the results of PCBs in blood testing annually.
- Collect concurrent dietary questionnaire information and information on other risk factors.

Use of Data

This data would provide state specific exposure distributions of PCBs in blood, which could potentially be used to monitor trends over time, identify high-risk populations, and occupational or behavioral risk factors for elevated PCBs (if blood samples were paired with a dietary or occupational exposure questionnaire).

Other Considerations

National data on PCB levels in blood will be collected by CDC, however Washington residents probably consume more seafood than the general U.S. population and state specific levels would be helpful (CDC, 2003). General population samples could be analyzed for other biomarkers.

References

ATSDR, 2000. Toxicological Profile for PCBs.

CDC, 2003. Second National Report on Human Exposure to Environmental Chemicals. Available on the web at: http://www.cdc.gov/exposurereport/

Biomonitoring Application Application Number: 9

Title: **DOH Health and Nutrition Examination Survey (HANES) for organophosphate metabolites in children.**

Aims

To characterize the distribution of organophosphate metabolite levels in urine in children in Washington State.

Background and Needs

Organophosphate pesticides are widely used in the U.S. to control insects on food crops, in buildings, on lawns and for mosquito control (CDC, 2003). The dialkyl phosphates are metabolites of organophosphate pesticides and can be detected in urine to provide information about exposure to organophosphate pesticides. Fungicides are used to control fungal growth on stored crops and can also be used as a disinfectant for home use (CDC, 2003). Fungicides, including *ortho*-phenylphenyl, can be monitored in urine to determine exposures.

CDC has begun monitoring the U.S. general population, including children, for organophosphate metabolites and the fungicide *ortho*-phenylphenyl (CDC, 2003). Several studies have investigated children's exposures to organophosphate pesticides in Washington State in agricultural communities (Fenske, et al., 2002; Curl, et al., 2002). These studies show that proximity to farms and parental occupational exposures to pesticides are important risk factors for children's exposures to organophosphate pesticides. Organophosphorus pesticide exposures have also been assessed for children in the Seattle area (Lu, et al., 2001). A recent study of 39 children in Seattle showed that children who eat a diet consisting of organic foods have lower organophosphate metabolites in urine (Curl, et al., 2003).

Methods

- Collect urine samples from a sample of children in the general population to estimate exposures to organophosphate pesticides and fungicides. Analyze urine samples for dialkyl phosphates and fungicides including *ortho*-phenylphenyl.
- Information on factors related to pesticide exposures including occupation of parents, proximity to farms, consumption of organic foods, and home pesticide use will be collected concurrently.

Use of Data

Data can be used to identify risk factors for elevated organophosphate pesticide and fungicide exposures. Results can be compared to national data being collected by CDC. Results can also be used as Washington State background values for comparing to studies of specific populations within the state and for monitoring changes in exposures over time.

Other Considerations
It may be difficult to collect accurate information on possible sources of exposures to organophosphate pesticides or fungicides. Urine samples analyzed for organophosphate metabolites represent exposures from the previous few days (CDC, 2003). Therefore data will provide a snapshot of exposures for this population and not average exposures over longer periods of time.

References
CDC, 2003. Second National Report on Human Exposure to Environmental Chemicals. Available on the web at: http://www.cdc.gov/exposurereport/

Fenske, R.A., et al., 2002. Children's exposure to chlorpyrifos and parathion in an agricultural community in central Washington State. Environmental Health Perspectives, 110(5): 549-553.

Curl, C.L., et al., 2002. Evaluation of take-home organophosphorus pesticide exposure among agricultural workers and their children. Environmental Health Perspectives, 110(12): A787-A792.

Curl, C.L., et al., 2003. Organophosphorus pesticide exposure of urban and suburban preschool children with organic and conventional diets. Environmental Health Perspectives 111(3): 377-382.

Lu, C., et al., 2001. Biological monitoring survey of organophosphorus pesticide exposure among preschool children in the Seattle metropolitan area. Environmental Health Perspectives 109:299-303.

Body Burdens in Specific Populations Which Consume Large Amounts of Fish

Biomonitoring Application Application Number: 10

Title: **DDT in breast milk of women eating fish with elevated levels of DDT.**

Aims

To characterize the distribution the levels of DDT and its metabolites in breast milk from nursing women who eat fish from areas with elevated levels of DDT in fish (e.g. from the Okanogan and Walla Walls rivers).

Background and Needs

The pesticide DDT was widely used until it was banned in the early 1970's. Exposure to DDT is associated with developmental effects and cancer. DDT, and its metabolites DDE and DDE, are persistent in the environment and have been shown to accumulate in the fatty tissues of animals and people, including breast milk (ATSDR, 1994). Young children are at risk from exposures to DDT due to possible effects on the developing nervous system.

DDT had been used extensively in Eastern Washington and elevated DDT levels have been found in Yakima River fish and in fish elsewhere in Washington (DOH, 1998; PSAMP, 2001; EPA, 2002; Tetra Tech Inc., 1996). Concentrations of DDT found in fish of the Okanogan and Walla Walla rivers are among the highest in the nation (Ecology, 2003). According to the 2000 U.S. census, 7486 women of child-bearing age (15-44 years old) lived in Okanogan County and 11,258 lived in Walla Walla County. These figures provide information on the size of the population living near the Okanogan and Walla Walla rivers who might be recruited for biomonitoring.

Methods

- Collect and analyze breast milk for DDT from women eating fish caught from the Okanogan and Walla Walla rivers. Breast milk samples will be analyzed for DDT, DDE and DDD.
- Summarize the results of DDT blood testing annually.
- Collect concurrent questionnaire information on diet and other risk factors.

Use of Data

These data would help identify high-risk populations, and provide information to improve outreach and educational efforts.

Other Considerations

The population of nursing women may be small and difficult to identify. There is considerable information on the benefits of breastfeeding, and discouraging breastfeeding may not be warranted.

References

ATSDR, 1994. Toxicological Profile for 4,4'-DDT, 4,4'-DDE, 4,4'-DDD (update).

Puget Sound Ambient Monitoring Program (PSAMP), 2001. Toxic contaminants in marine and anadromous fishes from Puget Sound, Washington. Results of the Puget Sound Ambient Monitoring Program Fish Component, 1989-1999. Washington Dept. of Fish and Wildlife. Available at www.wa.gov/wdfw/fish/psamp/toxiccontaminants.htm.

Ecology, 2003. Unpublished data for fish sampled from the Okanogan and Walla Walla Rivers. Washington State Department of Ecology.

EPA, 2002. Columbia River Basin Fish Contaminant Survey, 1996-1998. EPA 910/R-02-006.

Tetra Tech, Inc., 1996. Assessing human health risks from chemically contaminated fish in the Lower Columbia River. Final Report. Prepared for the Columbia River Bi-State Program

DOH, 1998. DDT and DDE transmission through breast milk: Yakima River basin. Washington State Department of Health.

Biomonitoring Application Application Number: 11

Title: **DDT in blood of Asian and Pacific Islanders in Washington State.**

Aims

To characterize the distribution the levels of DDT and its metabolites in blood of Asian and Pacific Islander populations in Washington State.

Background and Needs

The pesticide DDT was widely used until the early 1970's when it was banned. Exposure to DDT is associated with developmental effects and cancer. DDT, and its metabolites DDE and DDE, are persistent in the environment and have been shown to accumulate in the fatty tissues of animals and people (ATSDR, 1994). Young children are at risk from exposures to DDT due to possible effects on the developing nervous system. DDT had been used extensively in Eastern Washington and elevated DDT levels have been found in Yakima River fish and in fish elsewhere in Washington (DOH, 1998; PSAMP, 2001; EPA, 2002; Tetra Tech Inc., 1996; Ecology, 2003).

A recent fish consumption survey identified several Asian and Pacific Islander populations in King Co. Washington as consuming more fish than the general population (EPA, 1999). This survey indicates that these populations may be at risk for adverse health effects from DDT exposure through consumption of fish. However, no studies have examined biomarkers of DDT exposures in Asian and Pacific Islander populations in Washington to better quantify actual exposures. According to the 2000 U.S. census, there were 310,507 Asian and Pacific Islanders living in the Puget Sound region, 84,172 of whom were women between the ages 15-44 years old.

Methods

- Collect and analyze blood samples from Asian and Pacific Islander populations identified as being high fish consumers or consuming fish that are known to contain DDT.
- Blood samples will be analyzed for DDT, DDE and DDD.
- Collect concurrent dietary questionnaire information.

Use of Data

Blood DDT concentrations will be used to validate estimates of DDT exposures based on fish consumption survey data and DDT concentrations in fish and to identify high-risk subpopulations. Data would be used to better target communications and outreach information to high-risk groups.

Other Considerations

CDC is collecting national data on DDT in blood which can be used for comparison (CDC, 2003). It is unknown what cultural barriers may exist to drawing blood samples for this type of study. Blood samples could be analyzed for other biomarkers.

References

ATSDR, 1994. Toxicological Profile for 4,4'-DDT, 4,4'-DDE, 4,4'-DDD (update).

CDC, 2003. Second National Report on Human Exposure to Environmental Chemicals. Available on the web at: http://www.cdc.gov/exposurereport/

Puget Sound Ambient Monitoring Program (PSAMP), 2001. Toxic contaminants in marine and anadromous fishes from Puget Sound, Washington. Results of the Puget Sound Ambient Monitoring Program Fish Component, 1989-1999. Washington Dept. of Fish and Wildlife. Available at www.wa.gov/wdfw/fish/psamp/toxiccontaminants.htm.

Ecology, 2003. Unpublished data for fish sampled from the Okanogan and Walla Walla Rivers. Washington State Department of Ecology.

EPA, 1999. Asian and Pacific Islander seafood consumption study. EPA Region 10. EPA 910/R-99-003.

EPA, 2002. Columbia River Basin Fish Contaminant Survey, 1996-1998. EPA 910/R-02-006.

Tetra Tech, Inc., 1996. Assessing human health risks from chemically contaminated fish in the Lower Columbia River. Final Report. Prepared for the Columbia River Bi-State Program

DOH, 1998. DDT and DDE transmission through breast milk: Yakima River basin. Washington State Department of Health.

Biomonitoring Application Application Number: 12

Title: **DDT in blood of Native Americans in Washington State.**

Aims

To characterize the distribution the levels of DDT and its metabolites in blood of Native American populations in Washington State.

Background and Needs

The pesticide DDT was widely used until it was banned in the early 1970's. Exposure to DDT is associated with neurodevelopmental disorders and cancer. DDT, and its metabolites DDE and DDE, are persistent in the environment and have been shown to accumulate in the fatty tissues of animals and people (ATSDR, 1994).

DDT has been found in fish from Puget Sound, the Columbia River and other rivers throughout the state (DOH, 1998; PSAMP, 2001; EPA, 2002; Tetra Tech Inc., 1996; Ecology, 2003). Fish consumption surveys and other information have identified several Native American Tribes in Washington State as consuming more fish than the general population and consuming marine mammals (CRITFC, 1994; Toy et al., 1996; Suquamish Tribe, 2000; Sepez, 2001). These surveys indicate that these populations may be at risk for adverse health effects from DDT exposure through consumption of fish. However, no studies have examined biomarkers of DDT exposures in Native American populations in Washington to better quantify actual exposures.

According to the 2000 U.S. census, 57,853 Native Americans live in the Puget Sound area and 32,667 live in counties along the Columbia River. Young children and pregnant women are most at risk from exposure to DDT. The 2000 U.S. census reported that of Native Americans living in the greater Puget Sound area, 14,270 were women between the ages of 15-44 years old and 4,517 were children under 5 years old. The 2000 U.S. census reported that 7881 Native American women between age 15-44 years old and 2873 children under 5 years old lived in counties along the Columbia River.

Methods

- Collect and analyze blood samples from Native American populations identified as being high fish consumers or consuming fish that are known to contain DDT.
- Blood samples will be analyzed for DDT, DDE and DDD.
- Collect concurrent dietary questionnaire information.

Use of Data

Blood DDT concentrations will be used to validate estimates of DDT exposures based on fish consumption survey data and DDT concentrations in fish and to identify high-risk subpopulations. Data would be used to better target communications and outreach information to high-risk groups.

Other Considerations
It is unknown what cultural barriers may exist to drawing blood samples for this type of study or if the Tribes are interesting in obtaining this type of information. CDC is collecting national data on DDT in blood which can be used for comparison (CDC, 2003). It is unknown what cultural barriers may exist to drawing blood samples for this type of study. Blood samples could be analyzed for other biomarkers.

References
ATSDR, 1994. Toxicological Profile for 4,4'-DDT, 4,4'-DDE, 4,4'-DDD (update).

CDC, 2003. Second National Report on Human Exposure to Environmental Chemicals. Available on the web at: http://www.cdc.gov/exposurereport/

Puget Sound Ambient Monitoring Program (PSAMP), 2001. Toxic contaminants in marine and anadromous fishes from Puget Sound, Washington. Results of the Puget Sound Ambient Monitoring Program Fish Component, 1989-1999. Washington Dept. of Fish and Wildlife. Available at www.wa.gov/wdfw/fish/psamp/toxiccontaminants.htm.

The Columbia River Intertribal Fish Commission (CRITFC), 1994. A Fish Consumption survey of the Umatilla, Nez Perce, Yakama and Warm Springs Tribes of the Columbia River Basin.

Toy et al., 1996. A Fish Consumption Survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region.

The Suquamish Tribe, 2000. Fish Consumption Survey of the Suquamish Indian Tribe of the Port Madison Indian Reservation, Puget Sound Region.

Ecology, 2003. Unpublished data for fish sampled from the Okanogan and Walla Walla Rivers. Washington State Department of Ecology.

EPA, 2002. Columbia River Basin Fish Contaminant Survey, 1996-1998. EPA 910/R-02-006.

Tetra Tech, Inc., 1996. Assessing human health risks from chemically contaminated fish in the Lower Columbia River. Final Report. Prepared for the Columbia River Bi-State Program

DOH, 1998. DDT and DDE transmission through breast milk: Yakima River basin. Washington State Department of Health.

Sepez, J., 2001. Political and social ecology of contemporary Makah subsistence hunting, fishing and shellfish collecting practices. Doctor of Philosophy dissertation. University of Washington, Department of Anthropology.

Biomonitoring Application Application Number: 13

Title: **Dioxins in blood of Asian and Pacific Islanders in Washington State.**

Aims

To characterize the distribution of dioxin levels in blood of Asian and Pacific Islander populations.

Background and Needs

Dioxins refer to a group of chemicals that were contaminants in some previously used pesticides and that are formed during high temperature combustion. Dioxins are persistent environmental contaminants that build up in the fat of animals and people. Exposure to dioxins has been associated with developmental effects, impacts on the immune system, and cancer. Studies have linked dioxin levels in human blood with dietary intake of dioxins from fish (ATSDR, 1998).

Dioxins have been found in fish in several areas in Washington State (EPA, 2002; Tetra Tech Inc., 1996). A recent fish consumption survey identified several Asian and Pacific Islander populations in King County, Washington as consuming more fish than the general population (EPA, 1999). This survey suggests that these populations may be at risk for adverse health effects from dioxin exposure through consumption of fish. However, no studies have examined biomarkers of dioxin exposures in Asian and Pacific Island populations in Washington to better quantify actual exposures.

According to the 2000 U.S. census, 310,507 Asian and Pacific Islanders live in the Puget Sound area. Young children and pregnant women are most at risk from developmental effects of dioxin exposures. The 2000 U.S. census reported that of Asian and Pacific Islanders living in the greater Puget Sound area, 84,172 were women between the ages of 15-44 years old and 19,534 were children under 5 years old.

Methods

- Collect and analyze blood samples from Asian and Pacific Islander populations identified as being high fish consumers or consuming fish that are known to contain dioxins.
- Blood samples will be analyzed for individual dioxin congeners.
- Collect concurrent dietary questionnaire information.

Use of Data

Blood dioxins concentrations will be used to validate estimates of dioxin exposures based on fish consumption survey data and dioxin concentrations in fish and to identify high-risk subpopulations. Data would be used to better target communications and outreach information to high-risk groups.

Other Considerations

It is unknown what cultural barriers may exist to drawing blood samples for this type of study. No national data on dioxin levels in blood in the general population are currently

being collected for comparison. General population samples could be analyzed for other biomarkers. Background levels of dioxin exposures are thought to be at or near effects levels, so public health response would be unclear.

References

ATSDR, 1998. Toxicological Profile for chlorinated dibenzo-p-dioxins (update).

EPA, 1999. Asian and Pacific Islander seafood consumption study. EPA Region 10. EPA 910/R-99-003.

EPA, 2002. Columbia River Basin Fish Contaminant Survey, 1996-1998. EPA 910/R-02-006.

Tetra Tech, Inc., 1996. Assessing human health risks from chemically contaminated fish in the Lower Columbia River. Final Report. Prepared for the Columbia River Bi-State Program.

Biomonitoring Application Application Number: 14

Title: **Dioxins in blood of Native Americans in Washington State.**

Aims

To characterize the distribution of dioxin levels in blood of Native Americans in Washington State.

Background and Needs

Dioxins refer to a group of chemicals that were contaminants in some previously used pesticides and that are formed during high temperature combustion. Dioxins are persistent environmental contaminants that build up in the fat of animals and people. Exposure to dioxins has been associated with developmental effects, impacts on the immune system, and cancer. Studies have linked dioxin levels in human blood with dietary intake of dioxins from fish (ATSDR, 1998).

Dioxins have been found in fish in several areas in Washington State (EPA, 2002; Tetra Tech Inc., 1996). Fish consumption surveys have identified several Native American Tribes in Washington State as consuming more fish than the general population (CRITFC, 1994; Toy et al., 1996; Suquamish Tribe, 2000). Data collected from tribal fish consumption surveys along with measurements of dioxin concentrations in fish in the state have been used to estimate the amount of dietary intake of dioxins for tribal populations (EPA, 2002). These estimates indicate that some tribes may be at risk for adverse health effects from dioxin exposure through consumption of fish. However, no studies have examined biomarkers of dioxin exposures in tribal populations in Washington to better quantify actual exposures

According to the 2000 U.S. census, 57,853 Native Americans live in the Puget Sound area and 32,667 live in counties along the Columbia River. Young children and pregnant women are most at risk from exposure to the developmental effects of dioxins. The 2000 U.S. census reported that of Native Americans living in the greater Puget Sound area, 14,270 were women between the ages of 15-44 years old and 4,517 were children under 5 years old. The 2000 U.S. census reported that 7881 Native American women between age 15-44 years old and 2873 children under 5 years old lived in counties along the Columbia River.

Methods

- Collect and analyze blood samples from Native American populations previously identified as being high fish consumers and consuming fish that are known to contain dioxins.
- Blood samples will be analyzed for individual dioxin congeners.
- Collect concurrent dietary questionnaire information.

Use of Data
Blood dioxin concentrations will be used to validate estimates of dioxin exposures based on fish consumption survey data and to identify high-risk subpopulations. Data would be used to better target communications and outreach information to high-risk groups.

Other Considerations
It is unknown what cultural barriers may exist to drawing blood samples for this type of study or if the Tribes are interesting in obtaining this type of information. No national data on dioxin levels in blood in the general population are currently being collected for comparison. General population samples could be analyzed for other biomarkers. Background levels of dioxin exposures are thought to be at or near effects levels, so public health response would be unclear. Analysis of dioxin congeners in blood can be problematic.

References
ATSDR, 1998. Toxicological Profile for chlorinated dibenzo-p-dioxins (update).

The Columbia River Intertribal Fish Commission (CRITFC), 1994. A Fish Consumption survey of the Umatilla, Nez Perce, Yakama and Warm Springs Tribes of the Columbia River Basin.

Toy et al., 1996. A Fish Consumption Survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region.

The Suquamish Tribe, 2000. Fish Consumption Survey of the Suquamish Indian Tribe of the Port Madison Indian Reservation, Puget Sound Region.

EPA, 2002. Columbia River Basin Fish Contaminant Survey, 1996-1998. EPA 910/R-02-006.

Tetra Tech, Inc., 1996. Assessing human health risks from chemically contaminated fish in the Lower Columbia River. Final Report. Prepared for the Columbia River Bi-State Program.

Biomonitoring Application Application Number: 15

Title: **Mercury in hair of high consumers of canned tuna.**

Aims

To characterize the concentrations of mercury in hair of people identified as being high consumers of canned tuna.

Background and Needs

Mercury is released into the environment from many industrial sources, where is can be transformed to methylmercury. Methylmercury is a neurotoxin and is known to accumulate in the muscle of fish. Exposure to methylmercury can be especially harmful to the nervous system of the developing fetus and young children. Studies have linked mercury levels in human hair with dietary intake of methylmercury from fish. Studies have also linked mercury levels in hair with health effects involving the nervous system (ATSDR, 1999; NAS, 2000).

Methylmercury is commonly found in canned tuna. The Washington State Department of Health (DOH) advises that women limit their consumption of canned tuna to one 6-ounce can per week and that children under six eat less than one half a can of tuna (three ounces) per week in order to limit the intake of methylmercury (DOH, 2002). Women and children who eat canned tuna more than this may be at increased risk of health effects from exposure to methylmercury. People who may be higher consumers of canned tuna include people with limited food budgets who rely on canned tuna as an inexpensive source of protein, such as WIC participants (supplemental nutrition program for women and children). However, the number of people consuming canned tuna above DOH's recommendation is unknown. No studies have examined biomarkers of methylmercury exposures in people known to consume canned tuna regularly. This type of information could be used to better characterize exposures associated with eating canned tuna.

Methods

- Collect and analyze hair samples from people identified to eat canned tuna regularly.
- Collect concurrent dietary questionnaire information as well as information on risk factors such as other sources of mercury exposures.

Use of Data

These data would be used to determine if people who consume canned tuna above DOH's recommendations are at risk from exposure to methylmercury. This information would be used to better target communications and outreach information to high-risk groups.

Other Considerations

It may be difficult to identify and recruit people who consume large amounts of canned tuna. Since fish is a healthful source of many nutrients and is associated with health benefits, discouraging people from eating fish may be harmful to their overall health.

References

ATSDR, 1999. Toxicological Profile for Mercury (Update).

NAS, 2000. Toxicological effects of methylmercury. National Academy of Sciences, National Research Council, National Academy Press.

DOH, 2002. Fish Facts for Healthy Nutrition. Statewide Fish Advisory for Mercury. Available at: http://www.doh.wa.gov/fish/default.htm .

Biomonitoring Application Application Number: 16

Title: **Mercury in hair of recreational fishermen in Washington State.**

Aims

To characterize the concentrations of mercury in hair of Washington State fishermen known to catch fish high in methylmercury.

Background and Needs

Mercury is released into the environment from many industrial sources, where is can be transformed to methylmercury. Methylmercury is a neurotoxin and is known to accumulate in the muscle of fish. Exposure to methylmercury can be especially harmful to the nervous system of the developing fetus and young children. Studies have linked mercury levels in human hair with dietary intake of methylmercury from fish. Studies have also linked mercury levels in hair with health effects involving the nervous system (ATSDR, 1999; NAS, 2000).

Methylmercury has been found in some types of fish in several areas in Washington State (PSAMP, 2001; EPA, 2002, WA Dept. of Fish and Wildlife, 2001). Predatory fish, such as bass, have been found to have higher methylmercury concentrations than non-predatory fish species such as trout. In 2002, the Washington State Department of Fish and Wildlife issued approximately 643, 918 fishing licenses to adults under 70 years old living in Washington (WA Dept. of Fish and Wildlife, 2003). People who fish and their families who eat fish known to contain higher levels of methylmercury may be at increased risk of health impacts from exposure to methylmercury via their diets. No studies have examined biomarkers of methylmercury exposures in fisher populations or their families in Washington.

Methods

- Collect and analyze hair samples from fishermen and their families who catch fish from areas known to contain methylmercury. Hair samples could be collected pre- fishing season and post fishing season to look at changes related to exposures. Collect and analyze hair samples from a comparison population of fishermen and their families who do not fish in areas with methylmercury contamination or who catch fish known to be low in methylmercury.
- Collect concurrent dietary questionnaire information as well as information on other sources of mercury exposure.

Use of Data

This type of information could be used to better characterize exposures associated with eating different species of locally caught fish from different water bodies and would be used to identify high risk populations. Data would be used to better target communications and outreach information.

Other Considerations
Recent studies of "high end" fish consumers indicate that nearly 90% exceeded current EPA's reference dose (RfD) for mercury. It may be difficult to identify and recruit families for biomonitoring.

References
ATSDR, 1999. Toxicological Profile for Mercury (Update).

Washington Department of Fish and Wildlife, 2001. Mercury in sport fishes of Lake Whatcom, Washington, including a review of potential impacts to aquatic resources and people. Technical Report #FPT01-09.

Washington Department of Fish and Wildlife, 2003. Personal communication. This estimate includes combination, combination 2-day, freshwater and salt water licenses.

Puget Sound Ambient Monitoring Program (PSAMP), 2001. Toxic contaminants in marine and anadromous fishes from Puget Sound, Washington. Results of the Puget Sound Ambient Monitoring Program Fish Component, 1989-1999. Washington Dept. of Fish and Wildlife. Available at www.wa.gov/wdfw/fish/psamp/toxiccontaminants.htm.

EPA, 2002. Columbia River Basin Fish Contaminant Survey, 1996-1998. EPA 910/R-02-006.

NAS, 2000. Toxicological effects of methylmercury. National Academy of Sciences, National Research Council, National Academy Press.

Biomonitoring Application Application Number: 17

Title: **Mercury in hair of Asian and Pacific Islanders in Washington State.**

Aims

To characterize the concentrations of mercury in hair of Asian and Pacific Islanders.

Background and Needs

Mercury is released into the environment from many industrial sources, where is can be transformed to methylmercury. Methylmercury is a neurotoxin and is known to accumulate in the muscle of fish. Studies have linked mercury levels in human hair with dietary intake of methylmercury from fish. Studies have also linked mercury levels in hair with health effects involving the nervous system (ATSDR, 1999; NAS, 2000).

Methylmercury has been found in fish in several areas in Washington State including Puget Sound (PSAMP, 2001; EPA, 2002). A recent fish consumption survey identified several Asian and Pacific Islander populations in King County, Washington as consuming more fish than the general population (EPA, 1999). This survey indicates that some Asian and Pacific Islander populations may be at risk for neurotoxic effects from methylmercury exposure from eating fish. However, no studies have examined biomarkers of methylmercury exposures in Asian and Pacific Islander populations in Washington to better quantify actual exposures and to better predict possible neurotoxic health effects.

According to the 2000 U.S. census, 310,507 Asian and Pacific Islanders live in the Puget Sound area. Young children and pregnant women are most at risk from developmental effects associated with exposures to methylmercury. The 2000 U.S. census reported that of Asian and Pacific Islanders living in the greater Puget Sound area, 84,172 were women between the ages of 15-44 years old and 19,534 were children under 5 years old.

Methods

- Collect and analyze hair samples from Asian and Pacific Islander populations previously identified as being high fish consumers and consuming fish that are known to contain methylmercury. Hair samples will be analyzed for total mercury.
- Collect concurrent dietary questionnaire information as well as information on other possible sources of mercury exposures, such as dental amalgams.

Use of Data

Mercury concentrations in hair will be used to validate previous estimates of methylmercury exposures for this population based on fish consumption data and mercury concentrations in fish. Data would be used to identify groups with higher methylmercury exposures in order to better target communications and outreach information.

Other Considerations
An EPA funded study to examine mercury in hair of Asian and Pacific Islander populations fishing from Lake Washington may begin soon.

References
ATSDR Toxicological Profile for Mercury, March 1999, Update.

EPA, 1999. Asian and Pacific Islander seafood consumption study. EPA Region 10. EPA 910/R-99-003.

EPA, 2002. Columbia River Basin Fish Contaminant Survey, 1996-1998. EPA 910/R-02-006.

NAS, 2000. Toxicological effects of methylmercury. National Academy of Sciences, National Research Council, National Academy Press.

Puget Sound Ambient Monitoring Program (PSAMP), 2001. Toxic contaminants in marine and anadromous fishes from Puget Sound, Washington. Results of the Puget Sound Ambient Monitoring Program Fish Component, 1989-1999. Washington Dept. of Fish and Wildlife. Available at www.wa.gov/wdfw/fish/psamp/toxiccontaminants.htm.

Biomonitoring Application Application Number: 18

Title: **Mercury in hair of Native Americans in Washington State.**

Aims

To characterize the concentrations of mercury in hair of Native American Tribes.

Background and Needs

Mercury is released into the environment from many industrial sources, where is can be transformed to methylmercury. Methylmercury is a neurotoxin and is known to accumulate in the muscle of fish. Studies have linked mercury levels in human hair with dietary intake of methylmercury from fish. Studies have also linked mercury levels in hair with health effects involving the nervous system (ATSDR, 1999; NAS, 2000).

Methylmercury has been found in fish in several areas in Washington State in Puget Sound and the Columbia River (PSAMP, 2001; EPA, 2002). Fish consumption surveys have identified several Native American Tribes in Washington State as consuming more fish than the general population (CRITFC, 1994; Toy et al., 1996; Suquamish Tribe, 2000). Data collected from tribal fish consumption surveys along with measurements of methylmercury concentrations in fish in the state have been used to estimate the amount of dietary intake of methylmercury for tribal populations (DOH, 2001). These estimates indicate that some Tribes may be at risk for neurotoxic effects from methylmercury exposure. However, no studies have examined biomarkers of methylmercury exposures in tribal populations in Washington to better quantify actual exposures.

According to the 2000 U.S. census, 57,853 Native Americans live in the Puget Sound area and 32,667 live in counties along the Columbia River. Young children and pregnant women are most at risk from exposure to the developmental effects of methylmercury. The 2000 U.S. census reported that of Native Americans living in the greater Puget Sound area, 14,270 were women between the ages of 15-44 years old and 4,517 were children under 5 years old. The 2000 U.S. census reported that 7881 Native American women between age 15-44 years old and 2873 children under 5 years old lived in counties along the Columbia River.

Methods

- Collect and analyze hair samples from Native American populations previously identified as being high fish consumers and consuming fish that are known to contain methylmercury. Hair samples will be analyzed for total mercury.
- Collect concurrent dietary questionnaire information as well as information on other possible sources of mercury exposures, such as dental amalgams.

Use of Data

Mercury concentrations in hair will be used to validate previous estimates of methylmercury exposures for this population based on fish consumption data. Data would be used to identify groups with higher methylmercury exposures in order to better target communications and outreach information.

Other Considerations
It is unknown whether the Tribes are interesting in obtaining this type of information.

References
ATSDR Toxicological Profile for Mercury, March 1999, Update.

Puget Sound Ambient Monitoring Program (PSAMP), 2001. Toxic contaminants in marine and anadromous fishes from Puget Sound, Washington. Results of the Puget Sound Ambient Monitoring Program Fish Component, 1989-1999. Washington Dept. of Fish and Wildlife. Available at www.wa.gov/wdfw/fish/psamp/toxiccontaminants.htm.

The Columbia River Intertribal Fish Commission (CRITFC), 1994. A Fish Consumption survey of the Umatilla, Nez Perce, Yakama and Warm Springs Tribes of the Columbia River Basin.

EPA, 2002. Columbia River Basin Fish Contaminant Survey, 1996-1998. EPA 910/R-02-006.

NAS, 2000. Toxicological effects of methylmercury. National Academy of Sciences, National Research Council, National Academy Press.

Toy et al., 1996. A Fish Consumption Survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region.

The Suquamish Tribe, 2000. Fish Consumption Survey of the Suquamish Indian Tribe of the Port Madison Indian Reservation, Puget Sound Region.

DOH, 2001. Exposure Analysis of Five Fish Consuming Populations for Overexposure to Methylmercury.

Biomonitoring Application Application Number: 19

Title: **PBDEs in blood of Asian and Pacific Islanders in Washington State.**

Aims

To characterize the distribution of PBDE blood levels in Asian and Pacific Islander populations in Washington State.

Background and Needs

Polybrominated diphenyl ethers (PBDEs) have been widely used as flame retardants in a variety of consumer products. Levels of PBDEs in the environment, including fish, have been increasing. PBDEs are lipophilic and are structurally similar to PCBs and DDT, which are known to persist in the environment. There have not been efforts to analyze fish in Washington State for PBDEs, although their presence in fish is expected. Toxicity studies on PBDEs suggest possible thyroid effects, neurobehavioral effects, and cancer, however toxicity information on these chemicals is limited (McDonald, 2002; Branchi, 2002; ATSDR, 2002). PBDEs have been detected in human blood, breast milk and body fat samples.

A recent fish consumption survey identified several Asian and Pacific Islander populations in King County, Washington as consuming more fish than the general population (EPA, 1999). This survey indicates that these populations may be at risk for increase exposures to PBDEs from eating fish.

According to the U.S. census, 310,507 Asian and Pacific Islanders live in the Puget Sound area. Young children and pregnant women may be most at risk from exposures to PBDEs due to their suspected developmental effects. The 2000 U.S. census reported that of Asian and Pacific Islanders living in the greater Puget Sound area, 84,172 were women between the ages of 15-44 years old and 19,534 were children under 5 years old.

Methods

- Collect and analyze blood for PBDEs from Asian and Pacific Islander populations of Washington State.
- Collect concurrent dietary questionnaire information and information on other potential risk factors.

Use of Data

Blood PBDE concentrations will be to identify high-risk subpopulations.

Other Considerations

It is unclear how information on PBDEs in these populations would be used towards controlling release of these substances due to their widespread use in consumer products. Since there is limited toxicity information on these compounds, it is unclear how levels in blood would be interpreted in terms of health risks or in terms of comparison values. Analytical methods for PBDEs are similar to PCBs and DDTs.

References

ATSDR, 2002. Draft Toxicological Profile for PBBs and PBDEs.

MacDonald, 2002. A perspective on the potential health risks of PBDEs. Chemosphere, 46: 745-755.

Branchi, I., et al., 2002. Effects of perinatal exposure to a polybrominated diphenyl ether (PBDE 99) on mouse neurobehavioural development. Neurotoxicology, 23: 375-384.

Biomonitoring Application Application Number: 20

Title: **PBDEs in blood of Native Americans in Washington State.**

Aims

To characterize the distribution of PBDEs levels in blood of Native Americans.

Background and Needs

Polybrominated diphenyl ethers (PBDEs) have been widely used as flame retardants in a variety of consumer products. Levels of PBDEs in the environment, including fish, have been increasing. PBDEs are lipophilic and are structurally similar to PCBs and DDT, which are known to persist in the environment. There have not been efforts to analyze fish in Washington State for PBDEs, although their presence in fish is expected. Toxicity studies on PBDEs suggest possible thyroid effects, neurobehavioral effects, and cancer, however toxicity information on these chemicals is limited (McDonald, 2002; Branchi, 2002; ATSDR, 2002). PBDEs have been detected in human blood, breast milk and body fat samples.

Fish consumption surveys and other information have identified several Native American Tribes in Washington State as consuming more fish than the general population or consuming marine mammals, which are high in PBDEs (CRITFC, 1994; Toy et al., 1996; Suquamish Tribe, 2000; Sepez, 2001). These surveys indicate that some tribes may be at risk for exposures to PBDEs through consumption of fish and/or marine mammals. No studies have examined biomarkers of PBDE exposures in tribal populations in Washington.

According to the 2000 U.S. census, 57,853 Native Americans live in the Puget Sound area and 32,667 live in counties along the Columbia River. Young children and pregnant women may be most at risk from exposures to PBDEs due to their suspected developmental effects. The 2000 U.S. census reported that of Native Americans living in the greater Puget Sound area, 14,270 were women between the ages of 15-44 years old and 4,517 were children under 5 years old. The 2000 U.S. census reported that 7881 Native American women between age 15-44 years old and 2873 children under 5 years old lived in counties along the Columbia River.

Methods

- Collect and analyze blood for PBDEs from Native American populations of Washington State.
- Collect concurrent dietary questionnaire information and information on other potential risk factors.

Use of Data

Blood PBDE concentrations will be to identify high-risk subpopulations.

Other Considerations
It is unclear how information on PBDEs in these populations would be used towards controlling release of these substances due to their widespread use in consumer products. Since there is limited toxicity information on these compounds, it is unclear how levels in blood would be interpreted in terms of health risks or in terms of comparison values. Analytical methods for PBDEs are similar to PCBs and DDTs. It is unknown what cultural barriers may exist to drawing blood samples for this type of study or if the Tribes are interesting in obtaining this type of information.

References
ATSDR, 2002. Draft Toxicological Profile for PBBs and PBDEs.

MacDonald, 2002. A perspective on the potential health risks of PBDEs. Chemosphere, 46: 745-755.

Branchi, I., et al., 2002. Effects of perinatal exposure to a polybrominated diphenyl ether (PBDE 99) on mouse neurobehavioural development. Neurotoxicology, 23: 375-384.

Biomonitoring Application Application Number: 21

Title: **PCBs in blood of Asian and Pacific Islanders in Washington State.**

Aims

To characterize the distribution of PCB levels in blood of Asian and Pacific Islander populations.

Background and Needs

Polychlorinated Biphenyls (PCBs) are persistent environmental contaminants that were previously used as coolants and lubricants in transformers and other electrical equipment. Exposure to PCBs has been associated with impacts to the developing fetus, impacts on the immune system, and cancer. Studies have linked PCB levels in human blood with dietary intake of PCBs from fish. Studies have also linked PCB levels in blood of mothers with developmental effects on the nervous system of their children exposed in utero (ATSDR, 2000).

PCBs have been found in fish in several areas in Washington State (PSAMP, 2001; EPA, 2002; Tetra Tech Inc., 1996). A recent fish consumption survey identified several Asian and Pacific Islander populations in King Co. Washington as consuming more fish than the general population (EPA, 1999). Data collected from this fish consumption survey indicates that these populations may be at risk for adverse health effects from PCB exposure through consumption of fish. However, no studies have examined biomarkers of PCB exposures in Asian and Pacific Island populations in Washington to better quantify exposures from eating fish.

According to the 2000 U.S. census, 310,507 Asian and Pacific Islanders live in the Puget Sound area. Young children and pregnant women are most at risk from possible developmental effects from exposures to PCBs. The 2000 U.S. census reported that of Asian and Pacific Islanders living in the greater Puget Sound area, 84,172 were women between the ages of 15-44 years old and 19,534 were children under 5 years old.

Methods

- Collect and analyze blood samples from Asian and Pacific Islander populations identified as being high fish consumers or consuming fish that are known to contain PCBs. Blood samples will be analyzed for individual PCB congeners.
- Collect concurrent dietary questionnaire information.

Use of Data

Blood PCB concentrations will be used to validate estimates of PCB exposures based on fish consumption survey data and to identify high-risk subpopulations. Data would be used to better target communications and outreach information to high-risk groups.

Other Considerations

It is unknown what cultural barriers may exist to drawing blood samples for this type of study. CDC is collecting national data on PCBs in blood for comparison (CDC, 2003)

References

ATSDR, 2000. Toxicological Profile for PCBs.

CDC, 2003. Second National Report on Human Exposure to Environmental Chemicals. Available on the web at: http://www.cdc.gov/exposurereport/

Puget Sound Ambient Monitoring Program (PSAMP), 2001. Toxic contaminants in marine and anadromous fishes from Puget Sound, Washington. Results of the Puget Sound Ambient Monitoring Program Fish Component, 1989 - 1999. Washington Dept. of Fish and Wildlife. Available at www.wa.gov/wdfw/fish/psamp/toxiccontaminants.htm.

EPA, 1999. Asian and Pacific Islander seafood consumption study. EPA Region 10. EPA 910/R-99-003.

EPA, 2002. Columbia River Basin Fish Contaminant Survey, 1996-1998. EPA 910/R-02-006.

Tetra Tech, Inc., 1996. Assessing human health risks from chemically contaminated fish in the Lower Columbia River. Final Report. Prepared for the Columbia River Bi-State Program.

Biomonitoring Application Application Number: 22

Title: **PCBs in blood of Native Americans in Washington State.**

Aims

To characterize the distribution of PCB levels in blood of Native Americans.

Background and Needs

Polychlorinated Biphenyls (PCBs) are persistent environmental contaminants that were previously used as coolants and lubricants in transformers and other electrical equipment. Exposure to PCBs has been associated with impacts to the developing fetus, impacts on the immune system, and cancer. Studies have linked PCB levels in human blood with dietary intake of PCBs from fish. Studies have also linked PCB levels in blood of mothers with developmental effects on the nervous system of their children exposed in utero (ATSDR, 2000).

PCBs have been found in fish in several areas in Washington State including Puget Sound and the Columbia River (PSAMP, 2001; EPA, 2002; Tetra Tech Inc., 1996). Fish consumption surveys and other information have identified several Native American Tribes in Washington State as consuming more fish than the general population or consuming marine mammals, which are high in PCBs (CRITFC, 1994; Toy et al., 1996; Suquamish Tribe, 2000; Sepez, 2001). Data collected from tribal fish consumption surveys along with measurements of PCB concentrations in fish in the state have been used to estimate the amount of dietary intake of PCBs for tribal populations (EPA, 2002). These estimates indicate that some Tribes may be at risk for adverse health effects from PCB exposure through consumption of fish. However, no studies have examined biomarkers of PCB exposures in tribal populations in Washington to better quantify actual exposures

According to the 2000 U.S. census, 57,853 Native Americans live in the Puget Sound area and 32,667 live in counties along the Columbia River. Young children and pregnant women are most at risk from exposure to the developmental effects of PCBs. The 2000 U.S. census reported that of Native Americans living in the greater Puget Sound area, 14,270 were women between the ages of 15-44 years old and 4,517 were children under 5 years old. The 2000 U.S. census reported that 7881 Native American women between age 15-44 years old and 2873 children under 5 years old lived in counties along the Columbia River.

Methods

- Collect and analyze blood samples from Native American populations previously identified as being high fish consumers or consuming fish that are known to contain PCBs. Blood samples will be analyzed for individual PCB congeners.
- Collect concurrent dietary questionnaire information.

Use of Data
Blood PCB concentrations will be used to validate estimates of PCB exposures based on fish consumption survey data and to identify high-risk subpopulations. Data would be used to better target communications and outreach information to high-risk groups.

Other Considerations
It is unknown what cultural barriers may exist to drawing blood samples for this type of study or if the Tribes are interesting in obtaining this type of information. CDC is collecting national data on PCBs in blood for comparison (CDC, 2003).

References
ATSDR, 2000. Toxicological Profile for PCBs.

CDC, 2003. Second National Report on Human Exposure to Environmental Chemicals. Available on the web at: http://www.cdc.gov/exposurereport/

Puget Sound Ambient Monitoring Program (PSAMP), 2001. Toxic contaminants in marine and anadromous fishes from Puget Sound, Washington. Results of the Puget Sound Ambient Monitoring Program Fish Component, 1989-1999. Washington Dept. of Fish and Wildlife. Available at www.wa.gov/wdfw/fish/psamp/toxiccontaminants.htm.

The Columbia River Intertribal Fish Commission (CRITFC), 1994. A Fish Consumption survey of the Umatilla, Nez Perce, Yakama and Warm Springs Tribes of the Columbia River Basin.

Toy et al., 1996. A Fish Consumption Survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region.

The Suquamish Tribe, 2000. Fish Consumption Survey of the Suquamish Indian Tribe of the Port Madison Indian Reservation, Puget Sound Region.

EPA, 2002. Columbia River Basin Fish Contaminant Survey, 1996-1998. EPA 910/R-02-006.

Tetra Tech, Inc., 1996. Assessing human health risks from chemically contaminated fish in the Lower Columbia River. Final Report. Prepared for the Columbia River Bi-State Program.

Sepez, J., 2001. Political and social ecology of contemporary Makah subsistence hunting, fishing and shellfish collecting practices. Doctor of Philosophy dissertation. University of Washington, Department of Anthropology.

Body Burdens Over Time

Biomonitoring Application Application Number: 23

Title: **Urinary arsenic levels in individuals with known exposures to arsenic.**

Aims

To characterize the distribution of urinary arsenic levels in individuals with known exposures to arsenic.

Background and Needs:

Many Washington residents may be exposed to greater than normal amounts of arsenic in their water and soil. Of particular interest in Washington is the widespread contamination of soil due to past emissions of arsenic from the Tacoma and Everett Smelters (estimated at about 450,000 acres) and past use of lead arsenate pesticide (estimated at about 188,000 acres) (Area-Wide Soil Contamination Task Force, 2003). Although smelter emissions and pesticide use no longer contribute arsenic to the environment, past contamination from these sources will remain in surface soils for centuries where it can be an ongoing source of exposure to current and future residents. People with long-term exposure to environmental arsenic have increased risk of developing a wide variety of health problems including cardiovascular disease, diabetes mellitus, numerous skin problems, and several forms of cancer (ATSDR, 2000).

Urinary arsenic levels have been used to determine people's exposure to arsenic in soil. However, within and between person variability of urinary arsenic concentrations have not been well established. Having data on urinary arsenic variability is important for evaluating the significance of urinary arsenic data collected from people potentially exposed to high levels of arsenic in the environment.

Methods:

- Collect urinary arsenic measurements from people with potential sources of arsenic exposure, such as those living in areas of arsenic soil contamination.
- Collect concurrent dietary samples, drinking water samples and residential soil and dust samples in order to evaluate the contribution of these sources of arsenic exposure. Collecting dietary samples or other dietary information is important because some foods are known sources of arsenic, especially shellfish. Collecting drinking water samples is important since arsenic occurs naturally in groundwater in some areas of Washington State.
- Since there is little information on intra-individual variability of urinary arsenic concentrations over time, it will be important to collect repeated measures on individuals.
- Collect concurrent blood lead data since lead and arsenic are collocated in some areas around the state.

Use of Data
These data would be used to evaluate urinary arsenic levels collected from people with known exposures to arsenic. Data will be used to identify high-risk populations and to better target communications and outreach information.

Other Considerations
It may be difficult to accurately characterize all possible sources of arsenic exposures. National data on urinary arsenic levels are not being collected by CDC for comparison (CDC, 2003).

References
ATSDR Toxicological Profile for Arsenic, 2000.

Area-Wide Soil Contamination Task Force, 2003. Preliminary estimates of acres affected by various sources of arsenic. Personnel communication Jim W. White, DOH.

CDC, 2003. Second National Report on Human Exposure to Environmental Chemicals. Available on the web at: http://www.cdc.gov/exposurereport/

Biomonitoring Application Application Number: 24

Title: **Monitoring of breast milk for lipophilic environmental contaminants.**

Aims

Assess in utero, perinatal and maternal exposures to lipophilic environmental contaminants including PCBs, DDT and its metabolites, and dioxins by monitoring breast milk of nursing women living in Washington State.

Background and Needs

The pesticide DDT was widely used to control insects on agricultural crops and to control insects that spread diseases like malaria. DDT was banned in the U.S. in 1972 (ATSDR, 2000A). Polychlorinated Biphenyls (PCBs) were previously used as coolants and lubricants in transformers and other electrical equipment. PCBs are no longer manufactured in the U.S., however they remain in some electrical equipment in use today (ATSDR, 2000B). Dioxins refer to a group of chemicals that were contaminants in some previously used pesticides and are formed during high temperature combustion (ATSDR, 1998).

DDT, PCBs and dioxins are persistent in the environment and have been shown to accumulate in the fatty tissues of animals, including fish. These contaminants have also been shown to accumulate in fatty tissues of people, including breast milk fat (ATSDR, 1994). DDT, PCB, and dioxins in breast milk have been associated with dietary intake of these contaminants (ATSDR, 2000B; ATSDR, 1998; DOH, 1998). Exposure to DDT, PCBs and dioxins are associated with a variety of toxic effects on developing infants (ATSDR, 2000A; ATSDR, 2000B; ATSDR, 1998). Measuring levels of lipophilic environmental contaminants in breast milk can provide information on possible exposures to nursing infants, which is a sensitive population for effects from these contaminants. Concentrations of contaminants in breast milk can also provide information on the mother's body burden of these contaminants, which may indicate prior exposures to the infant in utero.

DDT had been used extensively in Eastern Washington and elevated DDT levels have been found in Yakima River fish and in fish elsewhere in Washington (DOH, 1998; PSAMP, 2001; EPA, 2002; Tetra Tech Inc., 1996; Ecology, 2003). PCBs and dioxins have been found in fish in several areas in Washington State including Puget Sound and the Columbia River (PSAMP, 2001; EPA, 2002; Tetra Tech Inc., 1996).

Fish consumption surveys and other information have identified Native American Tribes and Asian and Pacific Islander groups in Washington State as consuming more fish than the general population (CRITFC, 1994; Toy et al., 1996; Suquamish Tribe, 2000; Sepez, 2001, EPA, 1999). Data collected from tribal fish consumption surveys along with measurements of these contaminants in fish in the state have been used to estimate the amount of dietary intake of these contaminants for tribal populations (EPA, 2002). These estimates indicate that some Tribes may be at risk for adverse health effects from exposure to these compounds through consumption of fish. However, no studies have

examined biomarkers of exposures to these contaminants in the general population in Washington or in Native American tribes or Asian and Pacific Islanders to quantify actual exposures to these populations.

According to the 2000 U.S. census, a total of 1,292,645 women of childbearing age (15-44 years old) lived in Washington State. Of this total number, 22,858 were Native American women and 94,317 were Asian and Pacific Islander women. These populations provide information on the total number of women who may become pregnant and who may subsequently breastfeed their infants.

Methods

- Collect breast milk samples from nursing mothers and analyze samples for lipophilic compounds including PCBs, DDT, and dioxins.
- Concurrent information on risk factors related to possible exposures and body burden of these compounds will be collected such as dietary information, possible occupational exposures and breastfeeding history.
- Breast milk samples could be collected from a sample of women from the general populations or could target groups known to have potentially higher exposures to these contaminants via consumption of locally-caught fish.

Use of Data

Results will be compared to data in the literature to identify highly exposed groups and risk factors associated with higher exposures. No national monitoring of environmental contaminants in breast milk is underway for use in comparing to national data. Results could be used to validate estimates of exposures from fish consumption surveys if highly exposed subpopulations are targeted. Results can be used to better target educational information related to environmental exposures and breastfeeding.

Other Considerations

Identifying and recruiting women to provide breast milk samples may be difficult. Cultural barriers may exist if Native Americans or Asian and Pacific Islander populations are targeted. The health benefits of breastfeeding are well known. Special care must be taken to avoid inadvertently discouraging breastfeeding among new or expectant mothers recruited as participants. Methyl mercury, which accumulates in fish and is associated with developmental toxic effects, is not found in breast milk to the same extent as DDT, PCBs and dioxins. Monitoring of breast milk, therefore, will not address potential post-natal exposures from this environmental contaminant.

References

CDC, 2003. Second National Report on Human Exposure to Environmental Chemicals. Available on the web at: http://www.cdc.gov/exposurereport/

ATSDR, 1998. Chlorinated dibenzo-p-dioxins (update).

ATSDR, 2000A. Toxicological Profile for DDT, DDE and DDD. Draft for Public Comment.

ATSDR, 2000B. Toxicological Profile for Polychlorinated Biphenyls (PCBs).

EPA, 1999. Asian and Pacific Islander seafood consumption study. EPA Region 10. EPA 910/R-99-003.

EPA, 2002. Columbia River Basin Fish Contaminant Survey, 1996-1998. EPA 910/R-02-006.

Tetra Tech, Inc., 1996. Assessing human health risks from chemically contaminated fish in the Lower Columbia River. Final Report. Prepared for the Columbia River Bi-State Program.

The Columbia River Intertribal Fish Commission (CRITFC), 1994. A Fish Consumption survey of the Umatilla, Nez Perce, Yakama and Warm Springs Tribes of the Columbia River Basin.

Toy et al., 1996. A Fish Consumption Survey of the Tulalip and Squaxin Island Tribes of the Puget Sound Region.

The Suquamish Tribe, 2000. Fish Consumption Survey of the Suquamish Indian Tribe of the Port Madison Indian Reservation, Puget Sound Region.

DOH, 1998. DDT and DDE Transmission Through Breast Milk: Yakima River Basin. Washington State Department of Health

Effectiveness of Prevention Actions

Biomonitoring Application Application Number: 25

Title: **Follow-up testing of children with elevated blood leads.**

Aims

To track blood lead levels of children over time who are identified as having an elevated blood lead level.

Background and Needs

Lead in gasoline, paint and solder in food cans had historically been significant sources of lead exposure, however lead has generally been eliminated from these products (ATSDR, 1993). Current sources of lead exposure include lead paint in older homes, some pottery and other imported products containing lead, traditional folk remedies from Mexico, and lead brought home associated with occupational exposures (DOH, 2002). Lead contaminated soil has resulted from past emissions of lead and arsenic from the Tacoma and Everett Smelters (estimated at about 450,000 acres) and past use of lead arsenate pesticide (estimated at about 188,000 acres) (Area-Wide Soil Contamination Task Force, 2003).

Lead is harmful to brain development and can cause learning and behavioral problems. Children are especially sensitive to the toxic effects of lead. Elevated blood lead levels are used to assess lead exposures and have been associated with the neuro-behavioral effects of lead. Children's blood lead levels have been decreasing in the general population (CDC, 2003). Currently, the CDC defines an elevated blood lead level in children as 10 μg/dL or above (CDC, 2003). A Washington State Dept. of Health (DOH) study conducted in 1999 estimated the prevalence of elevated blood lead levels in 1 and 2 year olds at 0.9% for all children in the state and 3.8% in Hispanic children in central Washington (DOH, 2002). It is recommended that children who have an elevated blood lead test be retested to ensure blood lead levels decrease. Retesting is at the discretion of the child's health care provider. However, children with blood lead levels between 10-15 μg/dL may not be as aggressively retested. In 2002, 83 children had blood lead levels greater than 9 μg/dL reported to DOH's childhood blood lead registry. Fifty-one of these children had levels between 10-14 μg/dL (DOH, 2003).

Methods

- Identify a sample of children who have elevated blood lead levels using DOH's childhood blood lead registry. This sample will oversample children identified with blood lead levels between 10-15 μg/dL.
- Collect follow-up blood lead samples after intervention activities to track changes in blood lead levels over time in this sample of children. A series of blood lead testing after initial intervention should begin 1-2 months after intervention and be followed up in either 6 months or 1 year intervals.

Use of Data
Data would be used to ensure that intervention activities related to environmental lead sources are effective in reducing blood lead concentrations and that blood lead levels remain below CDC's trigger level of 10 μg/dL. As blood lead is an indicator of lead exposure for only the last 30-45 days, more sequential testing could further understanding about the usefulness of blood lead screening as an indicator of overall exposure to lead.

Other Considerations
Follow-up of some children may be difficult due to address changes or unwillingness to participate for several blood draws. There would need to be significant resources devoted to follow-up activities.

References
ATSDR, 1993. Toxicological Profile for Lead

DOH, 2002. The Health of Washington State. Chapter titled Childhood Lead Poisoning. Available on the web at: http://www.doh.wa.gov/HWS/default.htm

DOH, 2003. Personnel communication, Eric Ossiander, data from DOH's Childhood Blood Lead Registry.

Area-Wide Soil Contamination Task Force, 2003. Preliminary estimates of acres affected by various sources of arsenic. Personnel communication Jim W. White, DOH.

CDC, 2003. Second National Report on Human Exposure to Environmental Chemicals. Available on the web at: http://www.cdc.gov/exposurereport/

Biomonitoring Application Application Number: 26

Title: **Methamphetamine in blood of workers who clean up illegal drug labs and children living in homes that are former illegal drug labs.**

Aims

To identify possible methamphetamine exposures of workers who clean up illegal drug labs or children living in homes that were formerly illegal drug labs.

Background and Needs

Clandestine drug labs, where the illegal drug methamphetamine is manufactured, is a growing problem in Washington State. Drug labs were discovered in 373 residences in the state in 2002. There are currently approximately 28 contractors certified to clean up illegal drug labs in residences and other buildings (DOH, 2003A). There are guidelines for proper cleanup of illegal drug labs (DOH, 1996).

Methamphetamine is a potent central nervous system stimulant and its use can lead to addiction (DOH, 2003B). A variety of dangerous chemicals including explosives, solvents, and corrosive compounds are associated with the manufacture of methamphetamine. Methamphetamine can be measured in urine and this type of measurement has been used in workplace drug testing.

Methods

- Collect urine samples from workers certified to cleanup clandestine drug labs, pre- and post- cleanup. Urine samples would be collected over time.
- Collect urine samples from children living in homes that were formerly illegal drug labs.

Use of Data

Data would be used to assess effectiveness of personal protective equipment and training of workers. Data on children would be used to assess the effectiveness of cleanup standards.

Other Considerations

Exposures to methamphetamine may be too low to characterize with biomonitoring given personal protective equipment and low cleanup standards. It may be difficult to identify and recruit children for this type of monitoring.

References

DOH, 2003A. Personal communication, Carolyn Comeau, Clandestine Drug Lab program, Washington State Department of Health.

DOH, 2003B. Meth Fact Sheet. Washington State Department of Health. Available at: http://www.doh.wa.gov/ehp/ts/CDL/MethFS.htm

DOH, 1996. Guidelines for contamination reduction and sampling at illegal drug manufacturing sites. Available at: http://www.doh.wa.gov/ehp/ts/CDL/CDLGuidelines.pdf

Significance of Known Exposures in Specific Populations

Biomonitoring Application Application Number: 27

Title: **Cholinesterase monitoring of pesticide applicators in Washington State.**

Aims

Monitor the levels of blood cholinesterase of pesticide applicators who apply organophosphate and carbamate pesticides in Washington State.

Background and Needs

Acetylcholinesterase (AChE) is an important enzyme in the nervous system which breaks down the neurotransmitter acetylcholine. Organophosphate and N-methyl carbamate insecticides inhibit the normal action of AChE, resulting in over stimulation of postsynaptic cells (primarily nerves, glands, and smooth muscle). Blood cholinesterases (plasma ChE and RBC AchE) serve as biomarkers of this enzyme in the nervous system.

Currently, pesticide applicators are not routinely tested for cholinesterase. The Washington State Department of Labor and Industries is proposing to begin requiring cholinesterase testing of pesticide applicators. Monitoring of blood cholinesterase can be used to detect over exposures to organophosphate and carbamate pesticides before symptoms are evident. Agricultural growers estimate as many as 3,000 workers may qualify for monitoring in WA.

Methods

- Collect baseline blood cholinesterase activity levels (plasma ChE and RBC AchE) for all pesticide handlers who are expected to mix, load or apply toxicity class I or II OPs and N-methyl-carbamates for more than 30 hours in a 30 day period. Two baseline tests more than two days apart but not more than 14 days apart will be averaged to derive a baseline cholinesterase value for each individual worker.
- Alternatively, baseline blood cholinesterase data could be derived from monitoring a representative sample of volunteers through the licensing courses and obtain a population distribution for Washington pesticide applicators pre-season. This would address the issue that the wide range of baseline or "normal" values in the population are more a function of the variability in testing methodology than real variability between individuals.
- Collect blood cholinesterase levels from all covered pesticide applicators during each 30 day period during which workers mix, load or apply these products more than 30 hours.

Use of Data

Cholinesterase monitoring relies on a worker's baseline value rather than a population reference range. Method variability also requires that all monitoring be done with the same method and preferably the same lab. A database would need to be created that stored baseline and subsequent test results. Worker results should be expressed in % enzyme activity relative to baseline.

Many groups are interested in knowing whether or to what extent ChE monitoring will protect WA workers (i.e., catch depression in enzyme activity before symptoms develop). Many parties may want access to results of this data collection.

Other Considerations
If the proposed L&I rule is adopted, this testing will be mandated by January 2004. If DOH has capacity to offer free or subsidized testing via this grant, the lab may have a lot of business. If DOH charges for the testing then ownership of the data will need to be negotiated.

Cholinesterase testing usually requires a venous blood draw and a well-decontaminated arm. There are cultural beliefs which make many Hispanic unreceptive to blood draws. Participation can be maximized when subjects are recruited through clinics where workers receive their other health care.

References
L&I, 2002. Fact Sheet for Cholinesterase Monitoring, June 2002.

Presentation by Mike Gempler, Washington State Grower's League, at the PNW Pesticide Issues Conference: Agricultural health Issues 2/26/03, Yakima WA.

Biomonitoring Application Application Number: 28

Title: **Trihalomethanes in blood of consumers of chlorinated drinking water and people who swim in chlorinated pools.**

Aims

To monitor exposures to trihalomethanes in people who drink chlorinated drinking water and who swim in chlorinated pools.

Background and Needs

Trihalomethanes (THMs) are produced from the reaction of organic matter in water with chlorine used for disinfection. THMs, which include chloroform, have been detected in drinking water as well as swimming pools and spas. The U.S. EPA currently regulates the levels of total THMs in drinking water based on reducing potential cancer risks (EPA, 2002). Recent epidemiological studies suggest that exposure to THMs at levels below EPA's drinking water MCL may be associated with adverse pregnancy outcomes including low birthweight, neural tube defects, and stillbirths. Many of these studies rely on measuring THMs at the water utility for assessing exposures. Exposure to THMs can occur from ingestion of chlorinated drinking water and also from inhalation and dermal absorption of THMs during bathing, showering, and swimming. Measuring THMs in blood can be used to characterize exposure to these compounds and would provide integrated exposure estimates when addressing total exposures to THMs from all sources and exposure routes.

Eighty-two percent of Washington's residents receive their drinking water from large public water systems, most of which use chlorine for disinfection (DOH, 2002). Additionally, there are approximately 4000 public pools in Washington, and over 30,000 in-ground pools and 125,000 residential spa pools (DOH, 2003). THM levels in public pools are minimized with proper maintenance and compliance with organic matter standards.

Methods

- Collect blood samples from people in households who receive chlorinated drinking water.
- Collect concurrent questionnaire information on drinking water consumption, and other sources of THM exposures such as use of swimming pools and spas.
- Pair blood samples with concurrent testing of drinking water for THMs and water source characterization (identification of water supply utility).

Use of Data

These data would provide better estimates of relative contribution of different exposure sources to total THM exposure. Data would be used to validate questionnaire data and drinking water utility data as measures of THM exposure. Data could be used to advice pregnant women about potential exposures. Data could also be used to assist with linkage to birth defects data.

Other Considerations
THMs are short-lived in blood, so timing of biomonitoring is critical for assessing actual exposures. Recruiting participants and collecting appropriate samples could require significant resources.

References
Bove, F., et al., 2002. Drinking Water Contaminants and Adverse Pregnancy Outcomes: A Review. Environmental Health Perspectives, 110 (supplement 1): 61-74.

Dodds, L., et al., 2001. Relation between trihalomethane compounds and birth defects. Occupational and Environmental Medicine, 58: 443-446.

DOH, 2003. Personnel Communication, Gary Fraser, WA Dept. of Health. .

DOH, 2002. The Health of Washington State. Chapter on Drinking Water Quality. Available on the web at: http://www.doh.wa.gov/HWS/default.htm

EPA, 2002. Ground Water and Drinking Water Standards, Current Drinking Water Standards. Available at www.epa.gov/safewater/mcl.html.

Biomonitoring Application Application Number: 29

Title: **Monitoring of agricultural workers for organophosphate pesticide metabolites.**

Aims

Monitor the levels of organophosphate metabolites in urine of agricultural employees in Washington State.

Background and Needs

Organophosphate pesticides are widely used in the U.S. to control insects on food crops, in buildings, on lawns and for mosquito control (CDC, 2003). The dialkyl phosphates are metabolites of organophosphate pesticides and can be detected in urine to provide information about exposure to organophosphate pesticides.

Currently, agricultural workers in the state are not routinely monitored for pesticide exposures such as through testing of blood or urine. The Worker Protection Standard (WPS) requires agricultural employers to take certain steps to protect their employees from over exposure to pesticides. Employers are required to provide employee training, ensure personal protective equipment use, and restrict access to pesticide treated areas for prescribed time periods following pesticide application, i.e. restricted-entry interval. The Washington State Department of Labor and Industries is proposing to begin requiring cholinesterase testing of pesticide applicators. However, cholinesterase testing is aimed at a subset of agricultural workers (applicators) and detects exposures to a limited number of pesticides.

Methods

- Collect urine samples from agricultural employees to monitor their exposure to organophosphate pesticides and fungicides. Analyze urine samples for dialkyl phosphates.
- Information on factors related to pesticide exposures including job description, recent occupational location and activity, pesticide use, and personal protective equipment use will be collected concurrently.
- Identifying and collecting urine samples and other information about pesticide workers would need to be done in conjunction with Washington State Department of Agriculture and the Washington State Department of Labor and Industries.

Use of Data

Data will be used to evaluate the effectiveness of the WPS for protecting agricultural employees from exposures to pesticides. Monitoring can be used to identify highly exposed workers and can be used to target training or modifications in work practices. Results can be compared to national data being collected by CDC.

Other Considerations

Identifying and recruiting agricultural employees may be difficult. Willingness of employers to participate in monitoring is unknown.

References

Washington State Department of Agriculture (WSDA) 2002. Washington Pesticide Laws and other related regulations. Available at http://www.wa.gov/agr/PestFert/Pesticides/docs/PesticLawsBooklet.pdf

The Worker Protection Standard. WAC 16-233. Available at http://www.leg.wa.gov/wac/index.cfm?fuseaction=chapterdigest&chapter=16-233

CDC, 2003. Second National Report on Human Exposure to Environmental Chemicals. Available on the web at: http://www.cdc.gov/exposurereport/

Emerging Issues

Biomonitoring Application Application Number: 30

Title: **Emerging biomonitoring issues.**

Aims

To use biomonitoring to identify and characterize emerging environmental health issues.

Background and Needs

CDC has begun biomonitoring of the general population for a variety of chemicals associated with environmental exposures (CDC, 2003). Use of this information will include tracking trends of environmental exposures over time, identifying highly exposed subpopulations, establishing reference ranges of contaminants, and determining the prevalence of people with excessive or toxic levels of exposures. CDC is currently monitoring 116 chemicals in the general population. However, concerns about newly identified environmental contaminants constantly emerge. Examples include flame-retardants that are used widely in a variety of consumer products and perfluorooctanoic acid, which is released from products containing Teflon (ATSDR, 2002; The Washington Post, 2003). Further, advances in biomonitoring technologies may provide new surveillance tools. The purpose of this Application is to have a reserve of resources readily available to address emerging issues and/or to utilize new tools during the course of the five-year State Biomonitoring Plan.

Methods

- Analyze biological samples collected for other biomonitoring applications using analytical screening techniques to identify a range of contaminants.
- Use these data to identify contaminants that are frequently detected in existing applications.
- Research background on these contaminants to identify their possible sources. If feasible, develop applications to monitor these contaminants in the general population or in populations that may be more highly exposed.
- Take advantage of new biomonitoring technologies to address new and existing environmental health problems.

Use of Data

Will depend on specific issue addressed and techniques used.

Other Considerations

Such efforts may be very time consuming and may not yield productive results. This process may also require extensive resources. Toxicity information may not be available for interpreting health significance of biomonitoring results.

References

ATSDR, 2002. Draft Toxicological Profile for PBBs and PBDEs.

MacDonald, 2002. A perspective on the potential health risks of PBDEs. Chemosphere, 46: 745-755.

Branchi, I., et al., 2002. Effects of perinatal exposure to a polybrominated diphenyl ether (PBDE 99) on mouse neurobehavioural development. Neurotoxicology, 23: 375-384.

The Washington Post, 2003. EPA Probes Widely Used Chemical - Compound may pose health risk to women and young girls. April 15, 2003.

Attachment 5: Dr. Heyer's Final Report on the Stakeholder Interviews

Stakeholder Interviews Analysis Summary
Final Report
July 14, 2003

This is the final report by Nicholas Heyer, contractor, on the Department of Health's Public Health Laboratory Biomonitoring Planning Project stakeholder interviews that were conducted between March 18th and May 30th, 2003.

A total of 21 interviews were conducted by phone, and two participants completed and returned a questionnaire without a telephone interview. The duration of the telephone interviews ranged from about 45 minutes to over an hour and a half. Participants were almost always willing to fully discuss their views on biomonitoring, the role played by the Department of Health, and the role played by their organization (if they represented one).

Non-participation in the interview process occurred in several ways. In most cases, there was no response to e-mails or telephone calls. However, in a substantial number of cases, the person identified as a potential participant had moved from their position in the organization and were no longer available for interview. In one case, the designated participant did not feel she had enough information on the subject and declined an interview.

The 23 questionnaires completed included six (6) technical participants, eight (8) policymakers, and nine (9) community based organization participants. Following is a summary of their responses broken down by category: community, policy and technical.

There were a total of sixteen questions, six given to all groups, an additional four questions answered only by the policy and technical groups, and six additional questions answered only by the technical group. All groups answered the first three and last three questions, and these results are presented first. Policy and technical groups answered questions four through seven, and these results are presented next. Finally, only the technical group answered questions eight through thirteen, and these results are presented last.

An EXCEL file containing a worksheet for each question and a codebook supplements this report. More detailed answers to these questions by each participant are recorded. Each participant is identified by their group and a unique, but otherwise meaningless, ID number that allows the reader to track answers across questions.

I. Section One: Questions Answered by All Three Groups (Technical, Policy and Community)

Question 1: Which health conditions do you think are of greatest concern in Washington?

This question was vague for a number of participants. They were not sure whether this question referred to all possible health conditions or those related to environmental exposures and susceptible to tracking with biomonitoring. In these cases, I gave the participant the option of providing both responses. Thus, the number of conditions listed by each participant varies from one (1) to six (6). Some responses included multiple concerns and were coded into several categories. Responses included actual disease states, at risk physical condition (obesity), at risk behaviors (smoking/drinking), environmental exposures, and barriers to health care. In total, we had 100 responses that are summarized below in Table Q1.

Neurological development is a category suggested by the participants and is associated with immune and endocrine system disruption, developmental disabilities and even included multiple sclerosis for one respondent. The category of obesity is fairly straight forward, and I have included within it responses such as 'diet and exercise'. This response could also be seen as being closely related to the cardiovascular category, which also includes hypertension. Physical injuries include both occupational and motor vehicle injuries. General environment is a catchall category that includes hazardous home products, noise, and lack of green space. Health access includes cultural and language barriers to healthcare, as well as educational issues around health.

In interpreting these results, it is important to consider how decisions on grouping responses could easily change the perceived importance of a category. For example, lead, mercury and arsenic could have been grouped as heavy metals and thus been seen as a more prominent category with a larger total number of responses. Furthermore, it is difficult to draw strong conclusions from these small numbers. That being said, it is interesting how the five top categories (comprising almost half of all responses – 49%) are fairly evenly distributed between all participant categories. When one or two respondent categories do seem to stand out, this is indicated under the heading of "dominant group" which is abbreviated as "Dom. Gp." in the table.

Table Q1: Which health conditions do you think are of greatest concern in Washington?

Concern	Community	Policy	Technical	Total	Dom. Gp.
Neurological Development	6	4	2	12	-
Cancer	3	4	3	10	-
Obesity	4	5	1	10	-
Asthma	3	4	2	9	-
Smoking/Drinking	3	4	1	8	-
Cardiovascular	1	3	3	7	P/T
Pesticides	4	2	1	7	-
Lead	3	1	2	6	C/T
Mercury	1	2	2	5	P/T
Physical Injuries	1	3	0	4	P
Respiratory Problems	1	1	1	3	-
Diabetes	1	1	1	3	-
Water Quality	2	1	0	3	C/P
Air Quality	2	1	0	3	C/P
General Environment	3	0	0	3	C
Health Access	3	0	0	3	C
Flame Retardants	0	1	1	2	C/T
Arsenic	0	1	0	1	P
Hepatitis	1	0	0	1	C
TOTAL	42	38	20	100	

Question 2: How should we prioritize various uses of biomonitoring data?

This question posed several uses for biomonitoring data and asked respondents to rank them as high, medium or low. In a number of cases, respondent felt compelled to make their responses on the borders between these categories. Thus, I have created a 5-point scale with one (1) being 'high', five (5) being 'low', and three (3) being 'medium'. Two (2) and four (4) are border responses.

The respondents had a wide range of approaches to answering this question. Several felt that all these uses were high and were simply a continuum of the same usage. At least one respondent used short-term v. long-term goals as a method of prioritizing (short-term coming first, so being given a higher priority). Another respondent ranked a use that was not within the mandate of the DOH as a low priority. Another believed that biomonitoring was a valid gold standard of exposure and did not need confirmation by association with disease. However, these varied measures seem to have averaged out, and the responses, provided in Table Q2, show a fairly consistent picture

Table Q2: How should we prioritize various uses of biomonitoring data?

Use	Average Responses Community	Policy	Technical	Overall
Immediate public health action to intervene	1.7	1.9	2.7	2.0
Planning & evaluation				
Estimate magnitude of problem, track trends	1.8	1.5	1.7*	1.7
Identify high-risk groups, modifiable risk factors	1.2*	1.5	2.7	1.7
Assess effectiveness of control interventions	3.1	2.6	3.2	3.0
Etiologic studies	2.9	3.5	3.3	3.2

*Note: * indicate that all members but one of this group ranked the use a 'high (1).*

Question 3: Do you think that most people in your community would trust the state health department enough to allow scientists working for the state to collect samples of blood, saliva, etc.?

This question engendered a lot of discussion, which is summarized below. Table Q3 shows the distribution of responses on a four-point rating scale (1=trusted; 2=Requires Education; 3=Needs to Build Trust; 4=Reticence).

Community groups generally felt that the DOH could approach their communities, but that they would have to work through existing community groups to gain trust. They believed that the DOH needed to be clear in explaining their goals, how it will benefit the community and who will own the data. Much depends on the level of fear in the community. One community group member felt that the DOH had created trust through their immunization, med fly and SARS programs. On the other hand, another community member stated that while there are people within the DOH who are truly interested in community exposures, they did not feel that the department overall had much of a commitment to this issue.

Policymakers generally felt that the DOH was well positioned to do this type of work, and that it would be more trusted than the UW. Still, they generally believed that it would be necessary to go in and first educate the community around issues and solutions. Of course, the most effective situation is when the community perceives the problem themselves.

Technical participants were the most positive about the DOH. They felt it was the most appropriate organization to do this work. They were not aware of any problems with the reputation of the DOH.

Table Q3: Do you think that most people in your community would trust the state health department enough to allow scientists working for the state to collect samples of blood, saliva, etc.?

Group	Trusted	Requires Education	Needs to Build Trust	Reticence
Community	1	1	5	2
Policy	2	4	0	2
Technical	3	2	1	0
TOTAL	6	7	6	4

Question 14: If budget priorities require us to limit what we can do, which are the three most important issues you think we should focus on? Why?

The responses to this question were too varied to put into categories and summarize in a table. A summary paragraph for each group follows.

The community group hit on several themes. Perhaps the strongest theme was for DOH to interact with the community through partnering, education, outreach and follow-up on any activities they conduct. Much of the education and evaluation was focused on hazards for children. Another major theme requested the DOH to focus on high yield situations defined variously as bioaccumulating toxins, high-exposure and high-risk groups, growing exposures and well-known exposures. One community person did not want the DOH to focus, but wanted it to be able to evaluate a wide range of exposures whenever it did sampling to establish a knowledge base and track trends. Several focused on specific problem areas such as water and fish contamination and Hanford.

The policy group strongly focused on exposures relevant to children with concern about neurological and developmental problems. Another emphasis was on urging DOH to direct their energies where there was an opportunity to make an impact, focusing on chemical hazards specific to Washington State and creating a registry of exposure. A variety of specific concerns were mentioned including heavy metals, pesticides, cancer and arsenic, persistent chemicals and asthma and air pollution. Use of clear and understandable language by the DOH and the use of convenience samples were also recommended.

The technical group focused on the organization of data such as creating an asthma registry, an exposure-disease linkage system or an exposure map. They suggested seeking good research opportunities and focusing where exposures are likely to be high. They supported research and the search for less invasive biological monitoring techniques. A number of specific exposure concerns were mentioned, including three for lead, two for mercury and one each for arsenic and trihalomethanes.

Question 15: How has this interview changed your knowledge of or attitudes toward biomonitoring or the DOH PHL program.

Four of the nine community participants indicated that they did expand their knowledge about biomonitoring during this interview. Three stated that they were encouraged or energized, while an additional two confirmed that they supported the program. Four of the eight policy makers stated that the interview focused or perked their interests, while and additional showed support for the program. None of the technical people learned more about biomonitoring, but three showed their support for the program. None of the participants disparaged the program.

Question 16: Are there any other aspects of biomonitoring you'd like to comment on?

Two of the nine community participants took this opportunity to emphasize the inclusion of breast milk in a biomonitoring program, and two others warned the state that their approach to the community was critical. An additional two stressed their interest in working with the state. The eight policy makers expressed their concern about lack of knowledge around pesticides, and the endocrine interfering properties of some pharmaceuticals. Two addressed issues concerning how the DOH approaches the community groups. One listed issues around the incorporation of new technologies. Among the six technical participants, two stressed the need to link data. Another would like to see the state supplement what the university is doing. Another simply addressed issues about assessing needs and effectiveness, and suggested some research issues (e.g. paraquat and Parkinson's or lung cancer and arsenic).

II. Section Two: Questions Answered by the Technical and Policy Groups Only

Question 4: There are several groups of people who might benefit from biomonitoring. For each of the following groups, please tell me whether you think the group as defined is too narrow (ought to include a wider range of people), or too diffuse (ought to be a smaller more selective group), or appropriate?

The majority of respondents were not too critical of the way high-risk groups were defined. The biggest problem was with 'farmers using pesticides', where many felt that this was too broad and that it should specify applicators or pickers, or define those with direct exposures more effectively. Also, the category 'other workers with occupational exposures' was seen as too broad primarily for the way the question was asked, with no specific exposure or group given. One objection to defining a group of 'Tribal' or 'Asian' fish-eaters is that all fish eaters are at high-risk and that it was being too narrow to describe people by their racial or ethnic group. These groupings missed

other high quantity fish-eaters. On the other hand, it was pointed out that children are at highest risk and thus these categories were too broad and should focus on children. Thus, by focusing on separate issues, logical people could take opposite sides on these questions.

Other suggested groups included asthmatics (indoor air), proximity to superfund sites or toxic waste incinerators (plastics, mercury and dioxins), Eastern European fish consumers, Hispanic children (lead exposure), dental workers and auto recycling (mercury exposure), mine proximity (heavy metals in ground water), power plants (mercury and particulates), medical waste and genetic susceptibility.

Comments included remarks that all the categories are too broad resulting in problems with the public and with scientific review. Another comment suggested that we should be responsive to existing group structures rather than trying to single out certain groups. Responses are summarized in Table Q4.

Table Q4: There are several groups of people who might benefit from biomonitoring. For each of the following groups, please tell me whether you think the group as defined is too narrow (ought to include a wider range of people), or too diffuse (ought to be a smaller more selective group), or appropriate?

Group	Appropriate Pol/Tech	Narrow Pol/Tech	Broad Pol/Tech	NoAnswer Pol/Tech
Tribal fish consumers	3/3	2/1	1/0	2/2
Asian fish consumers	3/3	1/1	2/0	2/2
Ag-conversion land residents	3/2	0/0	2/1	3/3
Smelter proximity	3/3	0/0	2/0	3/3
Women of child-bearing age	2/2	0/0	2/1	4/3
Farmers using pesticides	0/2	2/2	5/2	1/0
Woodworkers using treated lumber	2/3	2/0	3/0	1/3
Other workers with occupational exp.	3/1	0/1	4/3	1/1
Children – lead screening	3/2	1/0	2/2	2/2
Children – other environmental chems	4/2	0/0	2/1	2/3
TOTAL	26/23	8/5	25/10	21/22

Question 5: Which chemicals do you feel ought to be a priority for biomonitoring?

Respondents were asked to rank their priorities (1=low, 2=medium and 3=high) for biomonitoring of specific exposures provided in a list. Most respondents did not have opinions on all these exposures listed, as can be seen by the relatively small number of responses for some chemicals in Table Q5. There were eight policy respondents and six technical respondents. The number responding to each exposure is given in parentheses. Arsenic, lead, mercury and pesticides had the largest total number of responses and were almost always assignment a high priority by respondents. Lesser-known chemicals

generated fewer responses and generally were given lower priority. One respondent rated cotinine as low because they felt it infringed on individual privacy.

Table Q5: Which chemicals do you feel ought to be a priority for biomonitoring?

	Average Responses (N)		
Chemical	**Policy**	**Technical**	**Overall**
Arsenic	2.9 (7)	3.0 (5)	2.9 (12)
Cotinine	1.6 (5)	3.0 (1)	1.8 (6)
Dioxins	2.5 (6)	1.5 (2)	2.3 (8)
Flame retardants (eg, PBDEs)	1.6 (5)	1.0 (1)	1.5 (6)
Lead	3.0 (7)	3.0 (4)	3.0 (11)
Mercury	3.0 (8)	3.0 (3)	3.0 (11)
Methamphetamine	2.0 (6)	1.0 (1)	1.9 (7)
PCBs, persistent organochlorines (DDT)	2.2 (6)	2.3 (3)	2.2 (9)
Pesticides	2.7 (7)	2.8 (5)	2.8 (12)
Phthalates, plasticizers	2.2 (5)	1.7 (3)	2.0 (8)
PAHs	2.6 (5)	2.0 (3)	2.4 (8)
THMs	2.0 (3)	1.5 (2)	1.8 (5)
Trichloroethylene (TCE), PCE	2.3 (3)	2.0 (1)	2.3 (4)

Other chemicals of concern that participants added to this list included beryllium, air pollution metals (chromium, vanadium and lithium – not enough is known about them), particulates in combination with chemical (acting as vehicles for and with enhanced toxicity due to these chemicals) and aflotoxin (although it was pointed out that this is not a problem in Washington state).

Question 6: If we were to conduct biomonitoring, should we always also be collecting exposure information, OR should we only collect exposure information afterwards on those individuals whose results are elevated? Why?

Five of the eight policy respondents thought we should always be collecting exposure data when conducting biomonitoring, while three thought we should only collect exposure data when biomonitoring results were high. Among the technical respondents, five wanted all the exposure data while only one wanted restricted data. Respondents favoring always collecting exposure data, while stating their reasons in different ways, were unanimous in their belief that there was not sufficient knowledge or understanding of how people reacted to exposures, and therefore, of how biological samples correspond to exposure. Among those favoring limited data, the predominant belief was that it would be too expensive and politically infeasible. One policy group respondent thought that biomonitoring was the gold standard and therefore exposure data was not really necessary while another thought that collecting the extra exposure data would falsely raise expectations. A technical respondent felt that collecting exposure

data when biomonitoring was low would be meaningless and believes we collect too many meaningless results.

Question 7: Of all of the possible specific biomonitoring ideas, which do you feel are politically infeasible? Why?

There was a wide range of issues presented, often not thought of as strictly political. Several people listed more than one issue. Three policy and two technical respondents thought that there was no particular political limitations on biomonitoring. Two of the policy people focused upon researchers who were self-limiting due to expediency or lack of rigor. One of the technical people thought that procedures were too invasive and there was a need for less invasive techniques. Again, three policy and two technical respondents mentioned occupationally related testing was opposed by management and therefore politically difficult. An additional three policy people thought that manufacturers and business opposed testing that might put an economic burden on them. Each example was quite different: dentist opposition to mercury testing in dentistry; manufacturer opposition to testing for flame retardant chemicals; and local business opposition to testing of fish mercury levels in Lake Chelan (supposedly some of the highest mercury concentrations in fresh water fish in the country). Ethical issues were also prominent and diverse. There were concerns about selecting minority groups (such as tribes or Asians) for testing, as well as focusing on school children. Another form of ethical issue was concern about disclosure of data to insurance companies or possible drug testing. One technical person simply pointed out resistance to linking state and national exposure data to health outcomes. There appeared to be no systematic differences in concerns between policy and technical respondents.

III. Section Three: Questions Answered by the Technical Group Alone

Question 8: Which tissue (matrix) is best suited for each Environmental Chemical/Toxic Substance? Where appropriate, indicate A = Acute, C = chronic

There was little discussion around these responses. Respondents simply listed off what they knew. However, one respondent was working on a saliva assay for lead to provide a less invasive measure. Responses are summarized in Table Q8. The number in parentheses indicates the number of responses followed by a letter indicating the measure is useful for acute (A) or chronic (C) or both (A/C) types of exposures. An underscore is used when this was not indicated.

Question 9: Which analytes? (metabolite? Environmental Chemical/Toxic Substance itself?)?

There was little discussion around these responses. Respondents simply listed off what they knew. However, one person pointed out that now they are finding metabolites being created in nature and exposures may be directly to these metabolites rather than the parent compound. Responses are summarized in Table Q9.

Table Q8: Which tissue is best suited for each Environmental Chemical/Toxic Substance?

Chemical	Suggested Tissue Matrix (Number & Acute or Chronic)
Arsenic	Urine (4A), Blood (3_)
Cotinine	Urine (3A/C), Saliva (2A), Blood (1_)
Dioxins	Blood (3A/C), Adipose (2C)
Flame retardants (e.g., PBDEs)	Blood (2_), Adipose (1C)
Lead	Blood (4A/C), Urine (1A), Bone (1_)
Mercury	Blood (3A), Urine (2A)
Methamphetamine	Urine (3A), Urine (1A), Saliva (1A)
PCBs, persistent organochlorines (DDT)	Blood (3A/C), Adipose (3C)
Pesticides	Urine (4A), Blood (3A/C), Saliva (1_)
Phthalates, plasticizers	no responses
PAHs	Blood (1A)
THMs	Breath (2A), Urine (1_)
Trichloroethylene (TCE), PCE	Urine (2A), Breath (2A)
Other - Berillium	Blood (1C)

Table Q9: Which tissue is best suited for each Environmental Chemical/Toxic Substance?

Chemical	Suggested Analyte
Arsenic	direct; MMA, DMA, As3, As5 (eliminate Arsine Petaine)
Cotinine	direct; this is the metabolite
Dioxins	direct, TCDD
Flame retardants (e.g., PBDEs)	no responses
Lead	direct, inorganic lead, ZPP, other markers
Mercury	direct, inorganic and methyl mercury, porphyrines
Methamphetamine	no responses
PCBs, persistent organochlorines (DDT)	various congomers - distinguish planar/non-planar
Pesticides	direct, metabolites (for OP's), cholinesterase (for OP's)
Phthalates, plasticizers	no responses
PAHs	Benzopyrenes, Dibenzopyrenes & metabolites
THMs	Chloroform, bromoform, bromotrichloromethane, Increase in trichloroacetic acid
Trichloroethylene (TCE), PCE	no responses

Question 10: What detection limits are optimal for each analyte?

There was little discussion around these responses. Respondents simply listed off what they knew. Very few respondents had specific information on this question and were uncertain of its meaning. Responses are summarized in Table Q10.

Table Q10: What detection limits are optimal for each analyte?

Chemical	Optimal Detection Limit
Arsenic	no responses
Cotinine	no responses
Dioxins	no responses
Flame retardants (e.g., PBDEs)	no responses
Lead	Electro-chemical with saliva - ppb range
Mercury	no responses
Methamphetamine	no responses
PCBs, persistent organochlorines (DDT)	no responses
Pesticides	generally high ppb range
Phthalates, plasticizers	no responses
PAHs	no responses
THMs	no responses
Trichloroethylene (TCE), PCE	no responses
Berylium	measure against controls & use ratio (causes sensitization)

Question 11: For which analytes is testing better done at a PHL partner laboratory, rather than DOH?

There was little discussion around these responses. Respondents simply listed off what they knew. Very few respondents had any information. Responses are summarized in Table Q11.

Question 12: For which Environmental Chemical/Toxic Substance is seasonality of testing important?

There was little discussion around these responses. Respondents simply listed off what they knew. Very few respondents had any information. Responses are summarized in Table Q12.

Table Q11: For which analytes is testing better done at a partner laboratory, rather than DOH?

Chemical	Partner Laboratory
Arsenic	Mayo Clinic (clinical samples); Kalman's UW lab
Cotinine	no responses
Dioxins	no responses
Flame retardants (e.g., PBDEs)	no responses
Lead	no responses
Mercury	no responses
Methamphetamine	no responses
PCBs, persistent organochlorines (DDT)	no responses
Pesticides	no responses
Phthalates, plasticizers	no responses
PAHs	no responses
THMs	no responses
Trichloroethylene (TCE), PCE	no responses
Berylium	National Jewish Medical Research (clinical samples)

Table Q12: For which Environmental Toxic Substance is seasonality of testing important?

Chemical	Seasonal Importance
Arsenic	Summer
Cotinine	no responses
Dioxins	Based on diet
Flame retardants (e.g., PBDEs)	no responses
Lead	no responses
Mercury	Heavy fishing periods
Methamphetamine	no responses
PCBs, persistent organochlorines (DDT)	no responses
Pesticides	Based on application patterns, closest / furthest from spraying season, dietary for kids
Phthalates, plasticizers	no responses
PAHs	no responses
THMs	no responses
Trichloroethylene (TCE), PCE	no responses
Air Pollution	During inversions in winter & summer

Question 13: "Convenience" sampling methods – prioritize sources

Respondents had limited information on this issue. One had concerns about archiving samples and problems with handling and preserving them. Another pointed out that autopsies are no longer regularly done and they would not yield a representative sample. It seems clear that non-traditional tissues did not rank high in these ratings. Responses are summarized in Table Q13.

Table Q13: "Convenience" sampling methods – prioritize sources

	"Convenience" Sampling Priority		
"Convenience" Sample	**High**	**Medium**	**Low**
Discarded blood from routine blood tests	3	1	0
Discarded urine from routine urine tests	2	1	1
Placental tissue	1	2	0
Amniotic fluid collected during amniocentesis	0	3	0
Tissue samples collected during surgical procedures	2	1	1
Tissue samples collected during routine autopsy	0	2	2

IV. Section Four: Summary

Respondents shared their ideas and opinions openly and generally with enthusiasm, happy to have the opportunity to give their input. Community participants generally had considerable knowledge on the subject, and represent an excellent resource for guiding the DOH in their interaction with the public. Even when they had some criticism of previous approaches, there was a willingness to participate in and improve future endeavors.

Policy participants were similarly well informed, and many seemed to understand the concerns of the community members and gave similar suggestions. This was also true for the technical participants. There was no real conflict in the interests and concerns of these groups, but somewhat different focuses. Community members focused primarily on the DOH interactions with the community. Policy members were concerned about focusing on children as a generally high risk group, while technical members focused on the use of the data, particularly in linking the data to make it more productive. It should be pointed out that these distinctions are generalities, and that many of these issues are shared across the groups.

The most important message from this survey is that there are active and involved communities at all levels throughout Washington State, and they are very interested in biomonitoring. The DOH has a wealth of knowledge and support available to them if they choose to take advantage of it.

Attachment 6: Cost Estimates

Table 1: Cost of Implementing Each Application Independently (rounded to the nearest $10,000)

	Start-Up (Year 1) Costs			Implementation (Subsequent Years) Costs per Year			
Application Title	**Lab**	**Field**	**TOTAL**	**Lab analysis**	**Lab personnel**	**Fieldwork**	**TOTAL**
Contaminants in breast milk of women with high aggregate exposures	$ 390,000	$ 130,000	$ 520,000	$ 50,000	$ 40,000	$ 370,000	$ 460,000
HANES for mercury in blood, urine and/or hair	$ 60,000	$ 440,000	$ 500,000	$ 150,000	$ 140,000	$ 560,000	$ 850,000
Urinary arsenic levels in individuals with known exposures to arsenic	$ 100,000	$ 130,000	$ 230,000	$ 20,000	$ 50,000	$ 370,000	$ 440,000
Children's exposure to OPs and fungicides	$ 150,000	$ 130,000	$ 280,000	$ 50,000	$ 10,000	$ 370,000	$ 430,000
Mercury in hair of Asian and Pacific Islanders	$ 60,000	$ 140,000	$ 200,000	$ 50,000	$ 40,000	$ 190,000	$ 280,000
Mercury in hair of Native Americans	$ 60,000	$ 140,000	$ 200,000	$ 50,000	$ 40,000	$ 190,000	$ 280,000
HANES for cotinine	$ 270,000	$ 440,000	$ 710,000	$ 40,000	$ 80,000	$ 560,000	$ 680,000
Ag workers exposure to pesticides re WPS	$ 20,000	$ 140,000	$ 160,000	$ 10,000	$ 20,000	$ 190,000	$ 220,000
Cholinesterase monitoring of pesticide applicators	$ 70,000	$ 140,000	$ 210,000	$ 5,000	$ 20,000	$ 190,000	$ 215,000
Resources for emergent issues	$ 390,000	$ 440,000	$ 830,000	$ 150,000	$ 150,000	$ 560,000	$ 860,000
Mercury in hair of high consumers of canned tuna.	$ 60,000	$ 140,000	$ 200,000	$ 50,000	$ 40,000	$ 190,000	$ 280,000
HANES for dioxins in blood	$ 390,000	$ 440,000	$ 830,000	$ 150,000	$ 150,000	$ 560,000	$ 860,000
HANES for DDT in blood	$ 390,000	$ 440,000	$ 830,000	$ 150,000	$ 150,000	$ 560,000	$ 860,000
HANES for urinary arsenic	$ 100,000	$ 440,000	$ 540,000	$ 150,000	$ 160,000	$ 560,000	$ 870,000
HANES for lead in blood	$ 20,000	$ 440,000	$ 460,000	$ 40,000	$ 50,000	$ 560,000	$ 650,000
HANES for PBDEs in blood	$ 390,000	$ 440,000	$ 830,000	$ 150,000	$ 150,000	$ 560,000	$ 860,000
HANES for PCBs in blood	$ 390,000	$ 440,000	$ 830,000	$ 150,000	$ 150,000	$ 560,000	$ 860,000
DDT in breast milk of women eating fish with elevated levels of DDT	$ 390,000	$ 140,000	$ 530,000	$ 50,000	$ 40,000	$ 190,000	$ 280,000
DDT in blood of Asian and Pacific Islanders	$ 390,000	$ 140,000	$ 530,000	$ 50,000	$ 40,000	$ 190,000	$ 280,000
DDT in blood of Native Americans	$ 390,000	$ 140,000	$ 530,000	$ 50,000	$ 40,000	$ 190,000	$ 280,000
Dioxins in blood of Asian and Pacific Islanders	$ 390,000	$ 140,000	$ 530,000	$ 50,000	$ 40,000	$ 190,000	$ 280,000
Dioxins in blood of Native Americans	$ 390,000	$ 140,000	$ 530,000	$ 50,000	$ 40,000	$ 190,000	$ 280,000
Mercury in hair of recreational fishermen	$ 60,000	$ 140,000	$ 200,000	$ 50,000	$ 40,000	$ 190,000	$ 280,000
PBDEs in blood of Asian and Pacific Islanders	$ 390,000	$ 140,000	$ 530,000	$ 50,000	$ 40,000	$ 190,000	$ 280,000
PBDEs in blood of Native Americans	$ 390,000	$ 140,000	$ 530,000	$ 50,000	$ 40,000	$ 190,000	$ 280,000

Attachment 6: Cost Estimates

Table 1 (continued): Cost of Implementing Each Application Independently

	Start-Up (Year 1) Costs			Implementation (Subsequent Years) Costs per Year			
Application Title	**Lab**	**Field**	**TOTAL**	**Lab analysis**	**Lab personnel**	**Fieldwork**	**TOTAL**
PCBs in blood of Asian and Pacific Islanders	$ 390,000	$ 140,000	$ 530,000	$ 50,000	$ 40,000	$ 190,000	$ 280,000
PCBs in blood of Native Americans	$ 390,000	$ 140,000	$ 530,000	$ 50,000	$ 40,000	$ 190,000	$ 280,000
Follow-up testing of children with elevated blood lead levels.	$ 20,000	$ 90,000	$ 110,000	$ 4,000	$ 10,000	$ 140,000	$ 154,000
Methamphetamine in blood of workers and children associated with illegal drug labs.	$ 390,000	$ 40,000	$ 430,000	$ 20,000	$ 10,000	$ 110,000	$ 140,000
Trihalomethanes (disinfection by-products) in blood associated with consumption of chlorinated drinking water and swimming pool use	$ 150,000	$ 140,000	$ 290,000	$ 30,000	$ 10,000	$ 190,000	$ 230,000

Table 2: Additional Costs of Implementing Application[1] (rounded to nearest $10,000)[2]

Application Title	Adv Comm rank	Start-Up (Year 1) Costs			Implementation (Subsequent Years) Costs per Year)					Cumulative Costs	
		Lab	Field	Total	Lab analysis	Lab personnel	Fieldwork	Implement per yr	Total	Start-up	Implement
Contaminants in breast milk of women with high aggregate exposures	1	$ 390,000	$ 130,000	$ 520,000	$ 50,000	$ 40,000	$ 370,000	$ 460,000	$ 460,000	$ 515,000	$ 426,000
HANES for mercury in blood, urine and/or hair	2	$ 60,000	$ 440,000	$ 500,000	$ 150,000	$ 140,000	$ 560,000	$ 850,000	$ 850,000	$1,020,000	$1,277,000
Urinary arsenic levels in individuals with known exposures to arsenic	3	$ 100,000	$ 130,000	$ 230,000	$ 20,000	$ 50,000	$ 370,000	$ 440,000	$ 440,000	$1,243,000	$1,675,000
Children's exposure to OPs and fungicides	4	$ 150,000	$ 130,000	$ 280,000	$ 50,000	$ 10,000	$ 370,000	$ 430,000	$ 430,000	$1,523,000	$2,092,000
Mercury in hair of Asian and Pacific Islanders	5	$ -	$ 140,000	$ 140,000	$ 50,000	$ 40,000	$ 190,000	$ 280,000	$ 280,000	$1,664,000	$2,343,000
Mercury in hair of Native Americans	6	$ -	$ 140,000	$ 140,000	$ 50,000	$ 40,000	$ 190,000	$ 280,000	$ 280,000	$1,805,000	$2,594,000
HANES for cotinine	7	$ 270,000	$ 10,000	$ 280,000	$ 40,000	$ 80,000	$ 10,000	$ 130,000	$ 130,000	$2,087,000	$3,255,000
Ag workers exposure to pesticides re WPS	8	$ 20,000	$ 140,000	$ 160,000	$ 10,000	$ 20,000	$ 190,000	$ 220,000	$ 220,000	$2,245,000	$2,933,000
Cholinesterase monitoring of pesticide applicators	9	$ 70,000	$ -	$ 70,000	$ 5,000	$ 20,000	$ -	$ 25,000	$ 25,000	$2,318,000	$2,948,000
Resources for emergent issues	10	$ -	$ 10,000	$ 10,000	$ 150,000	$ 150,000	$ 10,000	$ 310,000	$ 310,000	$2,327,000	$3,255,000
Mercury in hair of high consumers of canned tuna.		$ -	$ 140,000	$ 140,000	$ 50,000	$ 40,000	$ 190,000	$ 280,000	$ 280,000		
HANES for dioxins in blood		$ -	$ 10,000	$ 10,000	$ 20,000	$ 10,000	$ 10,000	$ 40,000	$ 40,000		
HANES for DDT in blood		$ -	$ 10,000	$ 10,000	$ 20,000	$ 10,000	$ 10,000	$ 40,000	$ 40,000		
HANES for urinary arsenic		$ -	$ 10,000	$ 10,000	$ 150,000	$ 160,000	$ 10,000	$ 320,000	$ 320,000		
HANES for lead in blood		$ -	$ 10,000	$ 10,000	$ 40,000	$ 50,000	$ 10,000	$ 100,000	$ 100,000		
HANES for PBDEs in blood		$ -	$ 10,000	$ 10,000	$ 20,000	$ 10,000	$ 10,000	$ 40,000	$ 40,000		
HANES for PCBs in blood		$ -	$ 10,000	$ 10,000	$ 20,000	$ 10,000	$ 10,000	$ 40,000	$ 40,000		
DDT in breast milk of women eating fish with elevated levels of DDT		$ -	$ 140,000	$ 140,000	$ 50,000	$ 40,000	$ 190,000	$ 280,000	$ 280,000		
DDT in blood of Asian and Pacific Islanders		$ -	$ -	$ -	$ 50,000	$ 40,000	$ -	$ 90,000	$ 90,000		
DDT in blood of Native Americans		$ -	$ -	$ -	$ 50,000	$ 40,000	$ -	$ 90,000	$ 90,000		
Dioxins in blood of Asian and Pacific Islanders		$ -	$ -	$ -	$ 50,000	$ 40,000	$ -	$ 90,000	$ 90,000		

[1] Rows 1-10 show the additional cost of implementing applications given that all of the applications in a preceding row have been implemented. Rows 11 and higher show the additional cost for implementing each application given that applications in rows 1-10 have all been implemented.

[2] Estimates less than $10,000 shown as '-'.

Table 2 (continued): Additional Costs of Implementing Application (rounded to nearest $10,000)

Application Title	Adv Comm rank	Start-Up (Year 1) Costs			Implementation (Subsequent Years) Costs per Year)					Cumulative Costs	
		Lab	Field	Total	Lab analysis	Lab personnel	Fieldwork	Implement per yr	Total	Start-up	Implement
Dioxins in blood of Native Americans		$ -	$ -	$ -	$ 50,000	$ 40,000	$ -	$ 90,000	$ 90,000		
Mercury in hair of recreational fishermen		$ -	$ 140,000	$ 140,000	$ 50,000	$ 40,000	$ 190,000	$ 280,000	$ 280,000		
PBDEs in blood of Asian and Pacific Islanders		$ -	$ -	$ -	$ 50,000	$ 40,000	$ -	$ 90,000	$ 90,000		
PBDEs in blood of Native Americans		$ -	$ -	$ -	$ 50,000	$ 40,000	$ -	$ 90,000	$ 90,000		
PCBs in blood of Asian and Pacific Islanders		$ -	$ -	$ -	$ 50,000	$ 40,000	$ -	$ 90,000	$ 90,000		
PCBs in blood of Native Americans		$ -	$ -	$ -	$ 50,000	$ 40,000	$ -	$ 90,000	$ 90,000		
Follow-up testing of children with elevated blood lead levels.		$ -	$ 90,000	$ 90,000	$ 4,000	$ 10,000	$ 140,000	$ 154,000	$ 154,000		
Methamphetamine in blood of workers and children associated with illegal drug labs.		$ -	$ 40,000	$ 40,000	$ 20,000	$ 10,000	$ 110,000	$ 140,000	$ 140,000		
Trihalomethanes (disinfection by-products) in blood associated with consumption of chlorinated drinking water and swimming pool use		$ -	$ 140,000	$ 140,000	$ 30,000	$ 10,000	$ 190,000	$ 230,000	$ 230,000		